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STRATIGRAPHY AND FORAMINIFERA OF THE REEF RIDGE SHALE, UPPER MIOCENE, CALIFORNIA

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ABSTRACT

The name Reef Ridge shale is proposed for a formation underlying the Etchegoin sands and overlying the redefined "McLure shale" of the Coalinga district, California. The Reef Ridge shale and the "McLure shale" are correlated with parts of the Maricopa shale and the Monterey shale. Foraminifera from the Reef Ridge shale are described (four new). The Reef Ridge shale is assigned to the upper Miocene.

The demarcation of Miocene and Pliocene epochs in the San Joaquin Valley, California, has been long under discussion. In recent years the lower Etchegoin formation has been generally regarded as of Pliocene age and the Santa Margarita formation as of Miocene age. Newest developments in geological research have disclosed the existence of a well-defined intermediary stage between Santa Margarita and lower Etchegoin. The name Reef Ridge shale is proposed for the distinctive formation deposited within this stage.

Acknowledgments.—The authors are deeply indebted to Mr. G. C. Gester, chief geologist of the Standard Oil Company of California, for the privilege of studying the company's collections and publishing the results. We are indebted to Messrs. John Galloway, G. M. Cunningham and Fritz E. von Estorff for making available to us the results of their wide experience on San Joaquin Valley geology; to Mr. E. Wayne Galliher, of the Hopkins Marine Station of Stanford University, for material from the type locality of the Monterey formation, near Monterey, California; to Mr. C. C. Church, Associated Oil Company, San Francisco, California, for material and suggestions; to Mr. Frank B. Tolman, of Stanford University, for many suggestions; and to Messrs. W. S. W. Kew, R. D. Reed, and Robert Kleinpell for reading and criticising the manuscript. Dr. Joseph A. Cushman has kindly furnished his opinion on the identification of several species. The core samples upon which this study was made were collected by various geologists and petroleum engineers. Finally, we wish to express our gratitude to Dr. Hubert G. Schenck, of Stanford University, for much valuable assistance during the early stages of this study and for attending to certain details in connection with the preparation of this paper for publication.

HISTORICAL REVIEW

Arnold and Anderson were the first to recognize the distinctive char-

acter of the Reef Ridge shale.[1] A formation, to which they applied the name "Santa Margarita (?)," was divided, near the southeast end of Reef Ridge, "into two main portions." The lower portion consists of "harder, more siliceous, and more thinly laminated purple and white shale and the upper of softer, more argilleacous brownish shale." Their upper division constitutes the present Reef Ridge shale. Along the northwest end of Reef Ridge the "Santa Margarita (?)," on their map and cross-section, consists only of their lower division. Their upper division, the present Reef Ridge shale, was referred to as a "Transition zone mapped as Jacalitos formation" in the latter area.[2]

While investigating the Etchegoin in the Coalinga district, Nomland discovered and described[3] an unconformity on the south side of Jasper Canyon. He suggested that this was the contact between the "Jacalitos" and the "Santa Margarita (?)" formations. As this unconformity lies at the top of Arnold and Anderson's "Transition zone" it definitely removes the zone from the "Jacalitos" formation. Nomland abandoned the term "Jacalitos" formation in favor of "lower Etchegoin" formation. In the present paper the series overlying the Reef Ridge shale will be referred to as Etchegoin sands, reverting to F. M. Anderson's older name.[4]

The term "McLure shale" has come into considerable use since its application in 1930 by Henny.[5] Henny's definition of "McLure shale" is: "The brown shale of the Coalinga region which was called Santa Margarita (?) by Arnold and Anderson." Because Arnold and Anderson were inconsistent in their mapping of the "Santa Margarita (?)," as stated above, Henny's definition of "McLure shale" obviously is ambiguous. Whether the name "McLure" is applicable to the present Reef Ridge shale and the lower division of Arnold and Anderson's "Santa Margarita (?)," or only to Arnold and Anderson's lower division is a matter of opinion. As no Reef Ridge shale is exposed in the type locality of the "McLure" shale and Henny's geologic map of the Waltham Creek—Reef Ridge area includes bands of Reef Ridge shale with the "Etchegoin" formation, it is believed that Henny had only the lower division of "Santa Margarita (?)" in mind when he proposed the new formational name. To avoid confusion, the "McLure shale" is to be regarded as the former "Santa Margarita" exclusive of the Reef Ridge shale.

DESCRIPTION OF THE REEF RIDGE SHALE

The Reef Ridge shale is typically exposed in a belt of degraded relief

[1] Arnold, Ralph, and Anderson, Robt., Geology and oil resources of the Coalinga district, California: *U. S. Geol. Survey Bull.* 398, p. 92, 1910.

[2] *Op. cit.*, pp. 100–101, fig. 4, and footnote.

[3] Nomland, J. O., The Etchegoin Pliocene of Middle California: *Univ. Calif. Publ. Bull. Dept. Geol. Sci.*, vol. 10, p. 201, 1917.

[4] Anderson, F. M., A stratigraphic study in the Mount Diablo Range of California: *Calif. Acad. Sci., Proc.*, 3d ser., Geology, vol. 2, no. 2, pp. 178–192, 1905.

[5] Henny, Gerard, McLure shale of the

on the northeast side of Reef Ridge, Fresno and Kings counties, California, from Little Tar Canyon to Jasper Canyon. The belt is flanked on the southwest by the more resistant "McLure shale" and the ridge-forming Temblor formation. On the northeast the cuesta topography of the Etchegoin sands looms prominently in contrast. Outcroppings of the Reef Ridge shale are generally poor and infrequent. These evidences can be taken to imply that the formation is relatively nonresistant to erosion.

The Reef Ridge shale of the type area is predominantly characterized by soft, blue (brown weathering), clay shale with minor beds of sandy shale. Toward the northwest end of the type belt there is an increase in sandiness and beds of brownish-gray sandstone enter.

The thickness of the formation appears to be somewhat variable from several measured sections. This variation in thickness seems to be due largely to unconformity at the top of the formation. However, the mechanics of measuring are subject to some error, due to poor exposures and a general masking of the contact of the Reef Ridge shale and the "McLure shale" by debris of the latter formation. Table I lists the thickness at several localities.

TABLE I

Locality	Measured by	Thickness in feet
Little Tar Canyon	Schenck, Galloway and Weatherston	395
Near old road 3¼ miles southeast of Big Tar Canyon	Galloway and Weymouth	170
East of Hill 2217	Schenck, Galloway and Weatherston	182
1 mi. E. of Hill 2787	Galloway and von Estorff	760
¾ mi. NE. of Hill 2787	Galloway and von Estorff	855
Zapato Creek west of Arroyo Pinoso	Barbat and von Estorff	400

The fossils known from the Reef Ridge shale of Reef Ridge consist of poorly preserved calcareous foraminifera and small leached diatoms. The foraminiferal fauna consists of species of *Buliminella*, *Bolivina*, *Virgulina*, and *Nonionella*. Although specific identifications of this material are hazardous, the fauna appears identical to that found in and described from Kettleman Hills where the preservation is somewhat better.

Relation to underlying beds.—The Reef Ridge shale rests upon a series of brown (white weathering) siliceous and diatomaceous shales and thin limestone lentils comprising the "Mc-

Coalinga region, Fresno and Kings counties, California: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 4, no. 4, pp. 403–410, 1930.

Lure shale." The "McLure shale," in turn, rests unconformably upon fossiliferous Temblor sandstones of middle Miocene age.

The "McLure shale"-Reef Ridge shale contact is not well exposed in the Reef Ridge area and it is somewhat obscure as many shale-on-shale contacts are. It is best traceable by a break in the soil, vegetation, and topography. In Zapato Canyon a poorly-sorted, leaf-bearing, basal sandstone occurs in the Reef Ridge shale and the contact has the appearance of a disconformity. The Reef Ridge shale overlaps the "McLure shale" north of Reef Ridge and rests in angular discordance on Cretaceous rocks. The overlap is traceable through the Coalinga field where cored wells show it to be accompanied by erosion of the underlying "McLure shale."

Age of the "McLure shale."—The "McLure shale" contains numerous impressions of discoidal diatoms, *Radiolaria*, and many specifically indeterminable arenaceous foraminifera. While these, in themselves, offer no clue as to the age of the "McLure shale" they are of interest because identical material is found in the Temblor Range in rocks of the same lithologic type. The equivalent of the "McLure shale" in the Temblor Range has been identified as the correlative of the Santa Margarita by Barbat and Weymouth.[6] This horizon is overlain by punky diatomite and underlain by foraminiferal lower Monterey shales. From the base of the lower Monterey shales (*Valvulineria californica* zone) to the top of the diatomite the beds in the Temblor Range have been shown to coincide with the Monterey formation at Monterey.

Except for one break in their continuity, the beds of the "McLure shale" can be traced into their Temblor Range equivalent. This break occurs in Antelope Valley, but paleontologic and lithologic correlations have been made across the break leaving no doubt as to their identity.

The lower Monterey (*Valvulineria californica* zone) of the Temblor Range disappears between the Temblor Range and Reef Ridge in a progressive overlap against the Temblor formation.

Northwest of Reef Ridge a fossiliferous sandstone intervenes between the Temblor formation and the "McLure shale." In Jacalitos Creek, in the north half of section 11, T. 22 S., R. 14 E., this sandstone has yielded the following fossils:

Pecten estrellanus Conrad
Pecten raymondi Clark
Pecten vickeryi Trask
Pecten crassicardo nomlandi Hertlein
Ostrea panzana Conrad
Dosinia cf. *arnoldi* Clark
Phacoides sp.?
Polonices sp.?

In Waltham Creek, Henny collected the following fossils in a sandstone described as unconformably underlying the "McLure shale":[7]

Tamiosoma gregaria Conrad

[6] Barbat, W. F. and Weymouth, A. Allan, Stratigraphy of the *Borophagus littoralis* locality, California: *Univ. Calif. Pub. Bull. Dept. Geol. Sci.*, vol. 21, no. 3, pp. 25–36, 1931.

[7] Henny, Gerard, *Op. cit.*, p. 406.

Pecten estrellanus Conrad
Pecten cf. *crassicardo nomlandi* Hertlein
Pecten raymondi Clark
Thais carisaensis Anderson
Chione semiplicata Nomland
Solen perrini Clark
Calyptraea cf. *martini* Clark
Astrodapsis sp. indet., "with prominent raised petals; not found below Santa Margarita."

The fauna from these two localities has been referred to as "Santa Margarita." Caution should be exercised in any correlation with the Santa Margarita. In the Salinas Valley area there are several horizons within the "Santa Margarita." There is one in particular that is lower than the Santa Margarita of the type section near the town of Santa Margarita. This horizon is closely related to the *Valvulineria californica* zone and therefore equivalent to the lower Monterey. It is correlated on paleontological grounds with the Briones formation of Contra Costa and Alameda counties. It contains the following fossils:[8]

Lucina acutilineata Conrad
Nuculana furlongi (Trask)
Nuculana cf. *taphria* Dall
Ostrea bourgeoisii Rémond
Ostrea panzana Conrad
Pecten crassicardo Conrad
Pecten crassicardo nomlandi Hertlein
Pecten estrellanus Conrad
Pecten raymondi Clark
Pecten vickeryi Trask
Spisula catiliformis Conrad
Yoldia cooperi Gabb. var.
Volsella recta (Conrad)
Astrodapsis sp. indet.; with raised petals, but found below Santa Margarita.
Cirripedia, genus (?)

The oyster and pecten fauna of the Waltham Creek and Jacalitos Creek localities points to a correlation with the Briones horizon of the lower Monterey. This is further verification of the Santa Margarita age of the "McLure shale."

Relation to overlying beds.—The Etchegoin sands rest with distinct unconformity upon the Reef Ridge shale along the northeast side of Reef Ridge. The lower beds of the Etchegoin sands contain many carbonized leaves and fragments of wood and are of possible terrestrial origin. A correlation with similar material north of Coalinga, which has furnished lower Pliocene vertebrates, is suggested. Lower Pliocene molluscan fossils are common above the basal beds.

DISTRIBUTION OF REEF RIDGE SHALE

Kettleman Hills.—The Reef Ridge shale forms a conspicuous unit in the Kettleman Hills well sections. In the early development of the North Dome of Kettleman Hills, the Reef Ridge shale was known as the "caving blue shale" because of the incapability of parts of it to stand in the walls of the wells. Core material shows it to be a very brittle, silty, nonorganic, blue shale, with a very marked tendency to spall or exfoliate

[8] Fossils from unnamed brown sandstone formation below white *Ostrea titan*-bearing sandstone equivalent to the Santa Margarita of the type locality and above fossiliferous Temblor sandstone. A shale bearing the *Valvulineria californica* zone fauna forms the basal member of the unnamed formation. Max Steineke collection; sections 27 and 35, T. 29 S., R. 17 E., M.D.B. & M., between San Juan River and Carrizo Plain, San Luis Obispo County, California. We are greatly indebted to Mr. Steineke for calling this important discovery to our attention.

when lightly tapped. Thin beds of fine, hard, gray sandstone occur in the upper half of the formation.

A few molluscan fossils have been found in Reef Ridge shale cores. These include *Acila* sp. ?, *Cancellaria* (?), *Cryptomya californica* (Conrad), *Ficus ocoyana* (Conrad), *Nuculana* sp., and *Siphonalia* (?). Pyritized diatoms are fairly common. The foraminiferal fauna is listed and described separately.

Well sections in the South Dome of Kettleman Hills have shown the formation to be 800 feet thick, in Middle Dome 716+ feet, and in North Dome 800 to 950 feet.

The basal beds of the overlying Etchegoin sands are usually poorly-sorted, muddy sands, and are characteristically dirty green in color. Plant carbon is frequently abundant.

The contact with the underlying "McLure shale" is sharp and distinctive. Local areas on North Dome show a basal sandstone in the Reef Ridge shale, and irregularities, suggestive of erosional unconformity, mark the contact. The "McLure shale" can be distinguished from the Reef Ridge shale by its brown color, hardness, and marked tendency to fracture in plate-like slabs. The upper "McLure shale" beds are also characterized by abundant impressions of large discoidal diatoms.

Coalinga district.—The Reef Ridge shale, greatly reduced in thickness, has been recognized in two cored wells in the West Side Coalinga field. It has been found in a cored well in the Guijarral Hills. Unconformities exist at both the top and bottom of the formation in this district. From southeast to northwest the Reef Ridge shale rests successively upon upper "McLure shale," lower "McLure shale," and Temblor formation. No attempt has been made to distinguish the Reef Ridge shale or its possible correlatives in the north of Coalinga area. It is recognized in surface exposures in Alcalde Canyon, to the west of Coalinga, where it rests in angular discordance on Cretaceous beds. A fossiliferous sandstone containing a basal Pliocene or even Miocene-Pliocene transition fauna overlies the Reef Ridge shale in the SW. ¼ SE. ¼ sec. 23, T. 21 S., R. 14 E. Mr. John Galloway, who has kindly furnished us with the data on this region, has collected the following fossils from this sandstone:

Amiantis callosa (Conrad) var. *stalderi* Clark
Amiantis dalli Clark
Dosinia ponderosa (Gray) var. *jacalitosana* Arnold
Laevicardium corbis (Martyn)
Macoma nasuta (Conrad)
Mactra albaria Conrad
Mactra densata (Conrad); ventricose form.
Mactra cf. *pabloensis* (Packard)
Panope generosa Gould
Pecten estrellanus (Conrad)
Polinices reclusianus (Deshayes) var. *andersoni* (Clark)
Sanguinolaria alta (Gabb) (?)
Turritella sp. (?)
Venus securis Shumard

This fossiliferous sandstone is separated from the main body of the Etchegoin sands by an angular unconformity which can be seen in an exposure at the bottom of Alcalde Canyon.

Lost Hills-Belridge district.—The Reef Ridge shale is believed to be

present in the Lost Hills-Belridge district of Kern County. Well sections in this district show evidence suggesting continuous deposition from Santa Margarita ("McLure shale" equivalent) into lower Etchegoin in local areas. Between portions of the section definitely referable to Santa Margarita and lower Etchegoin occurs a unit occupying the same stratigraphic position as the Reef Ridge shale. This is characteristically a light-colored, punky shale although gradation into the typical Reef Ridge lithology can be shown in certain instances. A foraminiferal fauna from the upper part of the Reef Ridge shale in the Belridge well is described below.

Chico-Martinez Creek.—The "Maricopa shale" of Chico-Martinez Creek, Kern County, California, has an upper member of punky, white, diatomite approximately 900 feet thick. Barbat and Weymouth[9] have shown that this member underlies *Pecten terminus*-bearing Etchegoin beds, that it is paleontologically correlated by use of diatoms with the upper diatomite of type Monterey, and that it overlies beds correlated with the type Santa Margarita formation. In relation to beds overlying and underlying, this Chico-Martinez Creek diatomite occupies a stratigraphic position identical to that of the Reef Ridge shale and a correlation is thereby suggested. Paul P. Goudkoff has recently found Reef Ridge foraminifera in this diatomite.[10]

[9] Barbat, W. F., and Weymouth, A. Allen, *Op. cit.*

[10] Oral announcement.

If this correlation is established, an explanation is offered for the lithologic facies of the Reef Ridge shale in the Belridge district. This facies can then be regarded as a rock type intermediate between nearshore diatomites and more basinward argillaceous shales. It is very significant that marginal portions of the southern San Joaquin basin and certain areas of older or continued uplift contain these punky and diatomaceous rocks whereas the deeper portions of the basin have Reef Ridge shale beds of the typical lithology.

Elk Hills-Semitropic Ridge district.—Beds, very similar in lithologic character to the Reef Ridge shale of Kettleman Hills, occur between Etchegoin sands and platy, brown "Maricopa shale" in Elk Hills and Semitropic Ridge well cores. The contacts between the Reef Ridge shale and the overlying and underlying formations are difficult to determine due to gradation of lithology resulting from uninterrupted deposition. Between 1,100 and 2,500 feet of beds in this district may be assigned to the Reef Ridge shale.

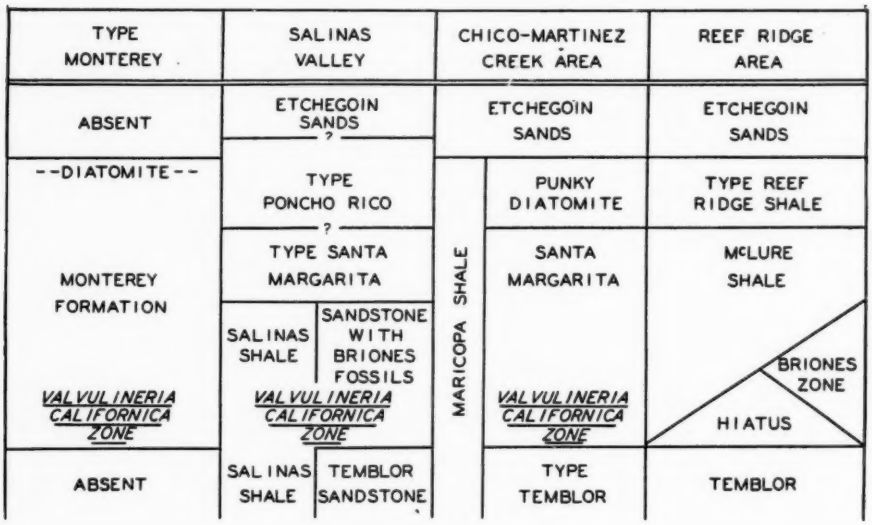
East side of Salinas Valley.—A portion of the Poncho Rico formation of the Salinas Valley (described by R. D. Reed[11] correlates with the Reef Ridge shale. Details of the Poncho Rico section are not at hand for strict comparisons. However a small group of samples, kindly furnished by Max Steineke, has shown that beds in the Poncho Rico district contain several horizons. An upper

[11] Reed, R. D., *Jour. Geology*, vol. 33, pp. 591–607, 1925.

horizon within the Poncho Rico section compares favorably with the lower Etchegoin. The Poncho Rico formation rests upon typical Santa Margarita formation.

The Kettleman Hills foraminifera occur in a dense blue clay-shale and are from near the base of the formation. The Belridge material is from near the top of the formation and occurs in a punky brownish-gray shale which is believed to be intermediate between the Kettleman Hills lithology and the diatomites of Chico-Martinez Creek. The fauna is small

CORRELATION OF CALIFORNIA FORMATIONS



FAUNA

The foraminiferal fauna of the Reef Ridge shale was secured from oil well cores from Kettleman Hills and from a well in the Belridge field.

Species	A	B	C	D	E	F
Nonion belridgensis n. sp.	×					
Nonionella miocenica Cushman	×	×	×	×		
Buliminella elegantissima (d'Orb.)	×	×	×	×	×	×
Buliminella dubia n. sp.	×	×		×		
Bulimina pseudotorta Cushman		×		×		
Virgulina californiensis Cushman		×	×	×		
Virgulina subplana, n. sp.		×				
Bolivina brevior Cushman		×	×	×		
Bolivina obliqua n. sp.		×				
Bolivina sp.		×				
Eponides exigua (H. B. Brady)	×					×
Quinqueloculina sp.	×					

A—Reef Ridge shale-Belridge
B—Reef Ridge shale-Kettleman Hills
C—Middle Miocene
D—Monterey shale Miocene
E—Etchegoin Pliocene
F—Recent

in number of species and individuals.

The foraminiferal fauna of the Reef Ridge shale shows decided Miocene relations. Six out of the ten determinable species are common to the Monterey shale and four are common to middle Miocene beds. Two species range into the Pliocene and Recent.

The faunal difference between the Kettleman Hills district and the Belridge well may be accounted for by ecological factors paralleling the change in lithologic facies as well as a slight difference in age.

SUMMARY

1. The Reef Ridge shale is a mappable unit with a small, but distinctive, foraminiferal fauna.

2. It is stratigraphically higher than Santa Margarita beds and underlies vertebrate and invertebrate zones in the Etchegoin sands of lower Pliocene age. Unconformities mark the top and bottom of the Reef Ridge shale in certain areas.

3. The Reef Ridge shale is correlated with the upper Monterey formation and with parts of the Maricopa shale and Poncho Rico formation.

4. The Reef Ridge shale is regarded as uppermost Miocene on the basis of the stratigraphic relations and faunal content.

DESCRIPTION OF SPECIES

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION BELRIDGENSIS Barbat and Johnson, n. sp.

Plate 1, figures 8, 9.

Test involute, bilaterally symmetrical, longer than broad, very slightly umbilicate, periphery acute; chambers numerous, 12 to 14 in last-formed coil; sutures slightly limbate in early portion, flush with surface near periphery, slightly depressed near umbilicus, curved, forming an acute angle with periphery; wall smooth, calcareous, finely perforate; apertural face heart-shaped. Length 0.47 mm., breadth 0.32 mm., thickness 0.24 mm.

This species resembles the middle Miocene form of *Nonion costifera* Cushman, but it is distinguished from the latter by the absence of limbate and costate sutures and has fewer chambers. It differs from a homeotype of *Nonion pizarrensis* Berry in having less depressed sutures and umbilici, the periphery is more acute, and the apertural face is broader.

A form almost identical, but with sutures slightly more limbate in the early portion of the test, and more depressed in the later portion has been found at L.S.J.U. locality 172, type locality of the Purisima formation, San Mateo County, California.

Holotype, Micropaleontology Laboratory, Stanford University, No. 836, Slide 850. Paratypes, 710, Slide 1139.

Locality.—L.S.J.U. 696, Ohio Oil Co. well, Bearstate No. 23, Belridge field, Kern County, California, McKittrick Quadrangle, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266–2286 feet.

Horizon.—Upper Reef Ridge shale, upper Miocene.

Genus NONIONELLA Cushman, 1926

NONIONELLA MIOCENICA Cushman

Plate 1, figures 1–4.

Nonionina auris CUSHMAN (not d'Orbigny), *1925*, Contr. Cushman Lab. Foram. Research, vol. 1, pt. 4, p. 91, pl. 13, figs. 4 *a–c*.
Nonionella miocenica CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Research, vol. 2, p. 64, *1927*, Bull. Scripps Institute Oceanography, Tech. Ser., vol. 1, p. 149.—CUSHMAN, STEWART and STEWART, *1930*, San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 61, pl. 8, figs. 6 *a-c*.

Test subtrochoid, the dorsal side only partly involute, the ventral side com-

pletely so, periphery moderately rounded; chambers inequilateral, usually nine to eleven in adult, ventral side of last chamber an elongate lobe extending toward and completely covering the umbilicus, coiling ambidextral; sutures curved and slightly depressed; wall calcareous, smooth, finely perforate. Length 0.38–0.47 mm., breadth 0.28–0.46 mm., thickness 0.19 mm.

A thin-section shows that the septa are formed by a curving in toward the umbilicus of the outer wall of the test. The wall and septa are approximately 0.015 mm. thick. No canal system was observed.

This form is very close to that described by Cushman from the Monterey of San Louis Obispo County, California, but differs from that described by Cushman, Stewart and Stewart from the Tertiary of Humbolt County, California, in having more chambers, a more broadly rounded periphery, and more curved sutures.

Plesiotypes, Micropaleontology Laboratory, Stanford University, 680; Slide 838.

Localities.—Abundant at L.S.J.U. No. 694, Continental Oil Co. well No. 13, Kettleman Hills, Kings County, California Coalinga Quadrangle, SW. ¼ sec. 2, T. 22 S., R. 17 E., M.D.M., depth 5,115–5,118; abundant at L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., depth 4,986 feet; abundant at L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E.; and rare at L.S.J.U. No. 696, Ohio Oil Co. well, Bearstate No. 23, Belridge field, Kern County, California, McKittrick Quadrangle, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266–2,286 feet.

Horizon.—Reef Ridge shale, upper Miocene.

Family BULIMINIDAE

Sub-family TURRILININAE

Genus BULIMINELLA Cushman, 1911

BULIMINELLA ELEGANTISSIMA (d'Orbigny)

Plate 1, figures 12, 13.

Bulimina elegantissima D'ORBIGNY, *1839*, Voy. Amér. Mérid., vol. 5, no. 5, "Foraminiferes," p. 51, pl. 7, figs. 13, 14.—H. B. BRADY, *1884*, Rep. Voy. Challenger, Zoology, vol. 9, p. 402, pl. 50, figs. 20–22.

Buliminella elegantissima CUSHMAN, *1911*, U. S. Nat. Mus., Bull. 71, pt. 2, p. 89; *1919*, Proc. U. S. Nat. Mus. vol. 56, p. 606; *1925*, Contr. Cushman Lab. Foram Research, vol. 1, pt. 2, p. 40, pl. 6, figs. 5*a*, *b*; *1930*, Florida Geol. Survey, Bull. no. 4, p. 42, pl. 8, figs. 2, 3.—CUSHMAN and KELLETT, *1929*, Proc. U. S. Nat. Mus., vol. 75, art. 25, p. 6, pl. 3, figs. 1–3.—CUSHMAN, STEWART and STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 64, pl. 4, figs. 7 *a*, *b*.—CUSHMAN and PARKER,

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EXPLANATION OF PLATE 1

FIGS. 1–4—*Nonionella miocenica* Cushman. ×70. 1, Ventral view; 2, apertural view; 3, dorsal view; 4, ventral view.

5–7—*Eponides exigua* (H. B. Brady). ×70. 5, Dorsal view; 6, apertural view; 7, ventral view.

8, 9—*Nonion belridgensis* Barbat and Johnson, n. sp. ×70. 8, Apertural view (holotype); 9, side view (paratype).

10—*Bulimina pseudotororta* Cushman. ×70.

11—*Quinqueloculina* sp. ×70.

12, 13—*Buliminella elegantissima* (d'Orbigny). ×70.

14, 15—*Buliminella dubia* Barbat and Johnson, n. sp. ×70. 14, Holotype; 15, paratype.

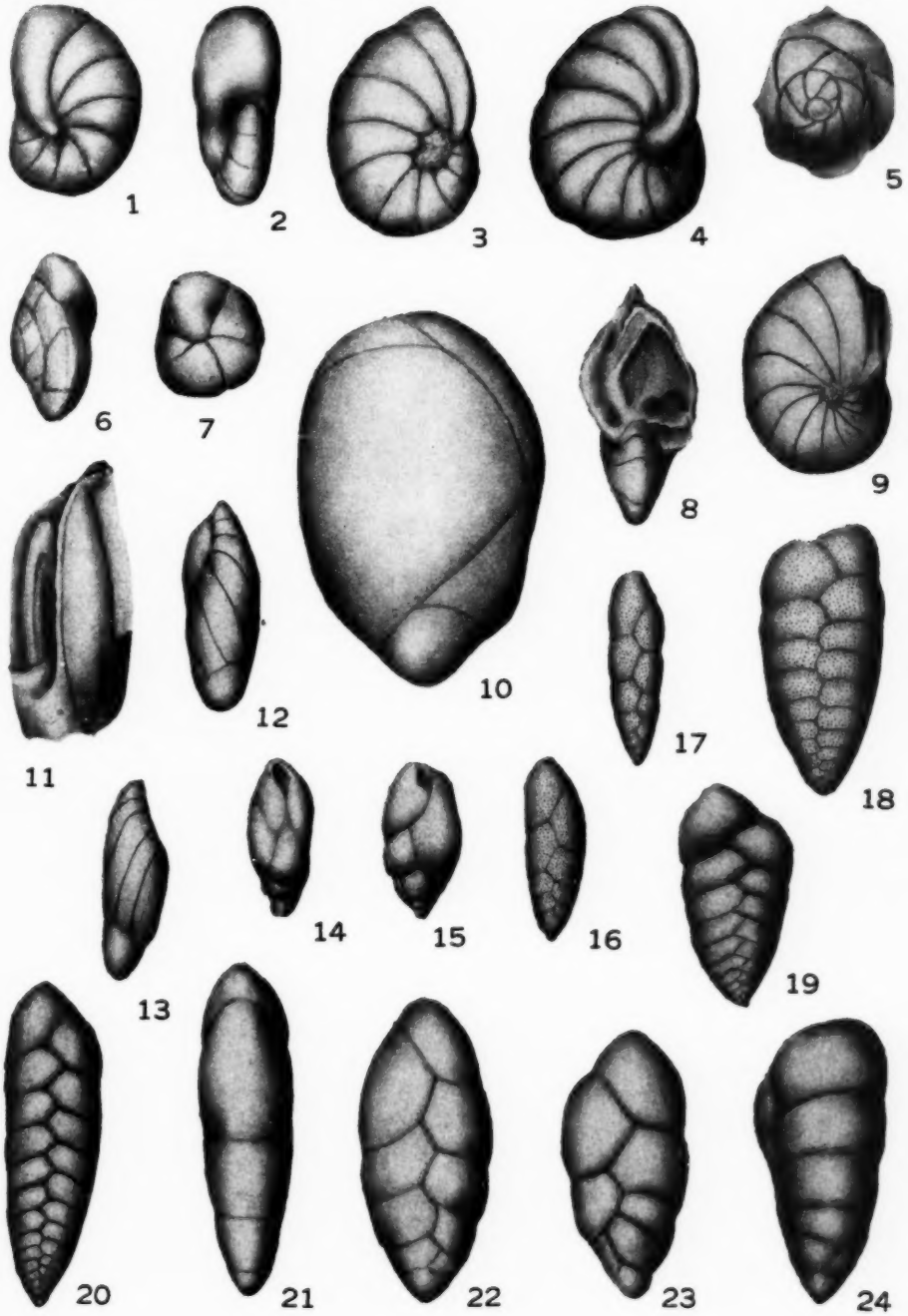
16, 17—*Virgulina subplana* Barbat and Johnson, n. sp. ×70. 16, Paratype; 17, holotype.

18—*Bolivina brevior* Cushman. ×140.

19—*Bolivina* sp. ×70.

20—*Bolivina obliqua* Barbat and Johnson, n. sp. ×70.

21–24—*Virgulina californiensis* Cushman. ×70. Figures 23 and 24 are immature specimens.



Barbat and Johnson, Miocene foraminifera

1931, Proc. U. S. Nat. Mus., vol. 80, art. 3, p. 13, pl. 3, figs. 12, 13.

Test elongate, distinctly spiral, consisting of about two and one-half whorls, the last of which occupies more than three-fourths of the shell, and in some specimens nothing but the last whorl can be seen; chambers vary from seven to ten in last whorl, are long in the direction of the test and set obliquely, very slightly inflated; sutures slightly depressed and slightly curved; wall smooth, calcareous, finely perforate; aperture an elongate, narrow slit set in a depression at the top of the last-formed whorl. The outer portion of the test on the initial end appears to be worn off as shown in the figures. Length 0.40–0.42 mm., breadth 0.14–0.16 mm.

This form appears to be identical with that figured by Cushman, Stewart and Stewart from the Tertiary of Humboldt County, California, and with that figured by Cushman from Florida. D'Orbigny's figures of this species from the west coast of South America have more whorls visible, and the initial end is more pointed. Cushman (Contr. Cushman Lab. Foram. Research, vol. 1, pt. 2, 1925, p. 40, pl. 6 figs. 5 *a*, *b*) mentions a recent form, very similar to d'Orbigny's original, from the coast of British Columbia.

Plesiotypes, Micropaleontology Laboratory, Stanford University; No. 682, Slide 840. Loc. 696, depth 2,266–2286.

Localities.—L.S.J.U. No. 696, Ohio Oil Co., Belridge field, Kern County, California, McKittrick Quadrangle, Bearstate well No. 23, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266–2,286 and 2,364–2,384 feet. This is a common species in the lower horizon of this well and less common in the upper; rare at L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, California, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth 5,465–5,484 feet.

Horizon.—Reef Ridge shale, upper Miocene. This species also ranges downward into the *Valvulineria californica* zone and Temblor beds.

BULIMINELLA DUBIA Barbat and Johnson, n. sp.

Plate 1, figures 14, 15.

Test spiral, consisting of about three and one-half whorls, tapering or fusiform, greatest width near apertural end, initial end pointed, apertural end rounded, periphery slightly lobulate; chambers distinct, about four in a whorl, almost as broad as long, more or less inflated; spiral suture not very distinct, other sutures well-marked, slightly depressed; wall calcareous, smooth, very finely perforate; aperture comma-shaped, located in a depression of the last-formed chamber. Length 0.31 mm.; width 0.17 mm.

This species has fewer chambers than *Buliminella curta*, and the chambers are broader in proportion to their length.

R. M. Kleinpell[12] reports this form from his uppermost *Valvulineria* zone.[13]

Holotype, Micropaleontology Laboratory, Stanford University, No. 683, Slide 841. Paratypes, 713, Slide 1142.

Locality.—Holotype and paratypes are from L.S.J.U. No. 696, Ohio Oil Company well, Bearstate No. 23, Belridge field, Kern County, California, McKittrick Quadrangle, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266–2,286 feet. It also occurs at L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Kings County, California, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., M.D.M., depth 4,986 feet, and at L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, California, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth 5,465–5,484 feet.

Horizon.—Reef Ridge shale, upper Miocene.

Genus BULIMINA d'Orbigny, 1826

BULIMINIA PSEUDOTORTA Cushman, 1926

Plate 1, figure 10

Bulimina pseudotorta CUSHMAN, *1926*, Contr. Cushman Lab. Foram. Research, vol.

[12] Oral communication.

[13] Unpublished M.A. thesis, Stanford University, 1928.

2, pt. 3, p. 55, pl. 7, fig. 3.—CUSHMAN, STEWART and STEWART, *1930*, Trans. San Diego Soc. Nat. Hist., vol. 6, no. 2, p. 66.

Test large, tapering, greatest width near apertural end, about one and one-half times as long as broad, initial end sharply rounded, apertural end very broadly rounded to almost truncate; chambers few, fairly distinct, considerably overlapping, very slightly inflated in some cases; sutures not very distinct, very slightly depressed; wall smooth, calcareous, finely perforate; aperture crescent-shaped. Length 0.77 mm., breadth 0.51 mm.

Cushman described the type of this species as having a cruciform aperture, but a homeotype from the Monterey formation of San Louis Obispo County, California, has a crescent-shaped aperture. This form with the crescent-shaped aperture has been found abundantly at L.S.J.U. Locality 662, in the *Nonion* division of the type Monterey (diatomite quarry 4 miles east of the city of Monterey).

Plesiotype, Micropaleontology Laboratory, Stanford University, No. 704, Slide 848. Loc. 695.

Localities.—L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Kings County, California, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., M.D.M., depth 4,986 feet; L.S.J.U. No. 694, Continental Oil Co. well No. 13, Kettleman Hills, Kings County, California, Coalinga Quadrangle, SW. ¼ sec. 2, T. 22 S., R. 17 E., M.D.M., depth 5,115–5,118 feet; L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, California, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth 5,465–5,484 feet.

Horizon.—Lower Reef Ridge shale, upper Miocene.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA CALIFORNIENSIS Cushman

Plate 1, figures 21–24

Virgulina californiensis CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, vol. 1, pt. 2, p. 32, pl. 5, figs. 11 *a–c*; *1931*. Jour. Paleontology, vol. 5, no. 2, p. 108, pl. 12, fig. 2 *a, b*.

Test a little over twice as long as broad, tapering toward both ends in adult form, initial end usually more pointed than apertural end, almost circular in cross-section or slightly compressed in some cases, sometimes twisted, periphery always broadly rounded; early chambers spiral, indistinct, small, later ones biserial, distinct, slightly inflated, increasing in size so that last three chambers make up about half of test; sutures in early portion indistinct, later ones distinct and depressed, making a large angle with periphery; wall calcareous, finely perforate; aperture comma-shaped, located at the tip of the last-formed chamber. Length 0.54–0.65 mm., breadth 0.25–0.26 mm., thickness 0.23 mm.

This species is the most abundant one found in this locality. Most of the forms seem to be a little stouter and longer than those described by Cushman from the Monterey shale of San Louis Obispo County, California. Cushman described the type as "not twisted." Although many of the forms found in this locality are twisted, this feature does not seem to be constant enough to justify naming a new species or variety. Figures 21 and 22 are not true representations of the species. The preservation was such that an accurate drawing was almost impossible. Figures 23 and 24 are immature specimens.

Plesiotypes, Micropaleontology Laboratory, Stanford University, No. 685, Slide 844.

Locality.—L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Kings County, California, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., M.D.M., depth 4,986 feet.

Horizon.—Lower Reef Ridge shale, upper Miocene.

VIRGULINA SUBPLANA Barbat and Johnson, n. sp.

Plate 1, figures 16, 17

Test elongate, tapering at both ends,

apertural end bluntly rounded, initial end sharp, slightly compressed on two sides, sometimes slightly twisted or curved, widest above the middle; chambers distinct, very slightly inflated, irregularly biserial, about five to six on each side; sutures distinct, slightly depressed, meeting the periphery almost at right angles; wall calcareous, finely and distinctly perforate; aperture an oval-shaped slit near tip of last chamber. Length 0.39 mm., breadth 0.12 mm.

This species has more chambers than *V. bramlettei* Galloway and Morrey, and is more compressed. From *V. compressa* (Bailey), it is distinguished by its sutures which meet the periphery almost at right angles.

Holotype, Micropaleontology Laboratory, Stanford University, No. 686, Slide 843. Paratypes, 684, Slide 842. Holotype and paratypes from Loc. 697.

Locality.—Abundant at L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, California, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth 5,465–5,484 feet; rare at L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Kings County, California, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., M.D.M., depth 4,986 feet.

Horizon.—Lower Reef Ridge shale, upper Miocene.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA BREVIOR Cushman

Plate 1, figure 18

Bolivina brevior CUSHMAN, *1925*, Contr. Cushman Lab. Foram. Research, vol. 1, pt. 2, p. 31, pl. 5, fig. 8 *a*, *b*; idem., vol. 2, pt. 3, p. 54.

Test minute, stout, a little over twice as long as broad, tapering from a subacute initial end, greatest width a little above the middle, decreasing slightly toward the almost truncate apertural end, periphery broadly rounded throughout; chambers biserial, about ten on each side, last five chambers making up half of test; sutures distinct, very slightly depressed, later ones with an upward-pointing lobe near median line of test (more pronounced than shown in figure); wall calcareous, finely and distinctly perforate. Length 0.26 mm., breadth 0.13 mm., thickness 0.09 mm.

This form appears to be the same as that described by Cushman from the "Monterey" formation (Miocene) of California. He did not mention the lobed sutures, but the test is so small that this feature might easily have been overlooked.

Plesiotype, Micropaleontology Laboratory, Stanford University, No. 702, Slide 846. Loc. 697.

Localities.—Rare at L.S.J.U. No. 695, Standard Oil Co. well No. 2, Kettleman Hills, Kings County, California, Lost Hills Quadrangle, sec. 35, T. 22 S., R. 18 E., M.D.M., depth 4,986 feet; common at L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth 5,465–5,484 feet.

Horizon.—Lower Reef Ridge shale, upper Miocene.

BOLIVINA OBLIQUA Barbat and Johnson, n. sp.

Plate 1, figure 20

Test moderately compressed, tapering from a sharply pointed initial end, very slightly if at all twisted, periphery broadly rounded; chambers slightly inflated, biserial, about 14 on each side in adult form, rapidly increasing in size from initial end; sutures very distinct, depressed, meeting periphery at an oblique angle; wall calcareous, finely perforate; aperture an elongate slit extending from the middle of the last chamber to the edge of the preceding chamber. Length 0.62 mm., breadth 0.21 mm.

This species resembles *Bolivina hughesi* Cushman, but differs from it in being less twisted and having more oblique sutures.

It has been compared by Dr. Cushman

with the type of *Bolivina seminuda* Cushman var. *foraminata* R. E. and K. C. Stewart, but he does not consider the two as the same species. In the latter species the chambers are higher in comparison to width and fewer in number, and the sutures are more curved.

Holotype, Micropaleontology Laboratory, Stanford University, No. 703, Slide 847. Paratype, 712, Slide 1141. Other paratypes are in the Paleontology Laboratory of the Associated Oil Co., San Francisco, California.

Locality.—L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, California, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., depth, 5,465–5,484 feet.

Horizon.—Lower Reef Ridge shale, upper Miocene.

BOLIVINA sp.?

Plate 1, figure 19

This form was compared by Dr. Cushman with *Bolivina decurtata*. The two are alike in many respects and Dr. Cushman suggests that they may be varietally distinct. However, since only one specimen was found, it does not seem advisable to name a new variety.

Type, Micropaleontology Laboratory, Stanford University, No. 711, Slide 1140.

Locality.—L.S.J.U. No. 697, Associated Oil Co. well, Whepley No. 1, Kettleman Hills, Kings County, Coalinga Quadrangle, sec. 35, T. 21 S., R. 17 E., M.D.M., Depth 5,465–5,484 feet.

Family ROTALIIDAE

Subfamily ROTALIINAE

Genus EPONIDES Montfort, 1808

EPONIDES EXIGUA (Brady)

Plate 1, figures 5–7

Pulvinulina exigua BRADY, *1884*, Rep. Voy. Challenger, Zoology, vol. 9, p. 696, pl. 103, figs. 13, 14, *a–c.*

Eponides exigua (H. B. Brady) (?) CUSHMAN, *1930*, Contr. Cushman Lab. Foram. Research, vol. 6, pt. 3, p. 60, pl. 8, figs. 11 *a*, *b*.

Test consisting of three or more coils, unequally biconvex, dorsal side usually the more convex, ventral side sometimes slightly umbilicate, periphery subacute, slightly lobulate; chambers distinct and sometimes slightly inflated on ventral side, all chambers visible on dorsal side, only those of the last-formed coil visible on ventral side, about five to seven in last coil and fifteen to seventeen in entire test; sutures slightly limbate, flush with surface and curved on dorsal side; not limbate, meeting the periphery nearly at a right angle on ventral side; wall smooth, calcareous, finely perforate; aperture an arched slit extending two-thirds of way to the umbilicus. Width 0.24–0.33 mm., thickness 0.18 mm.

Plesiotypes, Micropaleontology Laboratory, Stanford University, No. 681, Slide 839.

Locality.—L.S.J.U. No. 696, Ohio Oil Co. well, Bearstate No. 23, Belridge field, Kern County, California, McKittrick Quadrangle, sec. 30, T. 28 S., R. 21 E., M.D.M., depth 2,266–2,286 feet and 2,364–2,384 feet. This species is common at the lower depth, but occurs only rarely at the upper depth. The figured specimens are from 2,364–2,384 feet.

Horizon.—Upper Reef Ridge shale, upper Miocene.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA sp. ?

Plate 1, figure 11

A few poorly preserved fragments of this genus were found. Specific identification is impossible, but one fragment is figured for the sake of completeness.

Type, Micropaleontology Laboratory, Standford University, No. 705, Slide 849.

Locality.—L.S.J.U. No. 696, Ohio Oil Co. well, Bearstate No. 23, Belridge field, Kern County, California, McKittrick Quadrangle, sec. 30, T. 28 S., R. 21 E. M.D.M., depth 2,266–2,286 feet.

DESCRIPTION OF STANFORD UNIVERSITY FOSSIL LOCALITIES

694. Continental Oil Co., Kettleman Hills, Kings County, California, Coalinga Quadrangle, Well No. 13, SW. ¼ sec. 2, T. 22 S., R. 17 E., M.D.M. Elevation of well 998 feet above sea level. Depth 5,115–5,118 feet.

355. Standard Oil Co., Kettleman Hills,
(= Kings County, California, Lost Hills
695) Quadrangle, Well No. 2, sec. 35, T. 22 S., R. 18 E., M.D.M. Elevation of well 855 feet above sea level. Depth 4,986 feet.

696. Ohio Oil Co., Belridge field, Kern County, California, McKittrick Quadrangle, Bearstate No. 23, sec. 30, T. 28 S., R. 21 E., M.D.M. Elevation of well 682 feet above sea level. Depths 2,266–2,286 feet and 2,364–2,384 feet.

697. Associated Oil Co., Kettleman Hills, Kings County California, Coalinga Quadrangle, Whepley No. 1, sec. 35, T. 21 S., R. 17 E., M.D.M. Elevation of well 856 feet above sea level. Depth 5,465–5,484 feet.

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 1, PP. 18–20, PL. 2, MARCH, 1934

PSEUDOPARALEGOCERAS, A NEW GENUS OF CARBONIFEROUS AMMONOIDS

A. K. MILLER
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ABSTRACT

Paralegoceras peruvianum Berry [=*Gastroiceras pacificum* Thomas] of the Upper Carboniferous of Peru and *Gastroiceras russiense* Tzwetaev of the Upper Carboniferous of central Russia, though closely related to both *Paralegoceras* and *Gastrioceras*, represent a distinct genus for which the name *Pseudoparalegoceras* is proposed. Although the external sutures of these forms possess five primary lobes (as in *Paralegoceras*), their complete sutures possess only eight primary lobes (as in *Gastrioceras*)—there are no lobes on their umbilical walls. The holotypes of both of the known representatives of the new genus are illustrated and their sutures are represented diagrammatically. A discussion of the relationship between *Gastrioceras*, *Goniatites* s. s., and *Glyphioceras* is also included.

Although the occurrence of Carboniferous strata in South America was recorded by d'Orbigny[1] as early as 1842, no Carboniferous ammonoids were described from that continent until 1928. Early in that year Berry[2] published a description of a single fragmentary specimen which he had found the previous summer in the Upper Carboniferous of the Amotape Mountains of northwestern Peru, and he proposed the name *Paralegoceras peruvianum* for it. Shortly after the appearance of Berry's description there was published in England a paper by Thomas[3] in which several ammonoids were described from the same general horizon and locality.

Thomas noticed that one of his specimens, which he had described as *Gastrioceras pacificum*, is very similar to the form described by Berry, and he inserted a footnote in his manuscript to call attention to the possible identity of these two species. Professor Berry was kind enough to loan me the holotype of his species and I have compared it carefully with Thomas' figures and description and am reasonably certain that both forms represent the same species. Of course Berry's name, having priority, is the valid name of the species but it still remains to determine the proper generic designation to apply to this form. Berry referred it to *Paralegoceras* because its external sutures possessed two pairs of lateral lobes, whereas Thomas referred it to *Gastrioceras*

[1] D'Orbigny, Alcide, Voyage dans l'Amérique méridionale, t. 3, 1842.

[2] Berry, E. W., An ammonoid from the Carboniferous of Peru: *Am. Jour. Sci.*, ser. 5, vol. 15, pp. 151–153, 1928.

[3] Thomas, H. Dighton, An Upper Carboniferous fauna from the Amotape Mountains, northwestern Peru: *Geol. Mag.*, vol. 65, pp. 146–152, 215–234, 289–301, 1928; vol. 67, pp. 394–408, 1930.

because there are eight primary lobes in each of its complete sutures.

The genotype[4] of *Gastrioceras* is *G. listeri* (Martin) of the Lower Coal Measures of England, and possibly Belgium, Germany, and Arkansas. In each of its complete sutures there is a total of eight primary lobes; three of these are located on the external part of the conch, three on the internal, and two on the intermediate zones, that is, on the umbilical walls (see Pl. 2, fig. 6). The genotype of *Paralegoceras* is *P. iowense* (Meek and Worthen) of the Lower Pennsylvanian of Iowa and possibly Texas. In each of its sutures there are five primary lobes on the external part of the conch and two on the umbilical walls; the nature of its internal sutures is unfortunately not known but undoubtedly they are like those of such similar forms as *Paralegoceras newsomi* Smith and possess three lobes. It follows then that the complete sutures of typical representatives of *Gastrioceras* possess a total of eight primary lobes, three of which are external, whereas the complete sutures of typical representatives of *Paralegoceras* possess a total of ten primary lobes, five of which are external. The South American species under consideration coincides with neither of these conditions for although each of its external sutures possesses five primary lobes (as in *Paralegoceras*), each of its complete sutures possesses a total of only eight primary lobes (as in *Gastrioceras*)—there are no lobes on its umbilical walls. Externally, then, this form is indistinguishable from *Paralegoceras*, but when its complete sutures are taken into consideration it seems to be more closely related to *Gastrioceras* than to *Paralegoceras*. Karpinsky[5] long ago pointed out that precisely the same condition exists in the Russian species *Gastrioceras russiense* Tzwetaev, which Hyatt,[6] basing his opinion solely on external characters, referred to *Paralegoceras*.

So many species in which each complete suture possesses a total of eight primary lobes have been described and referred to *Gastrioceras* that the genus has become unwieldy, and there is a growing tendency to subdivide it into a number of genera (or subgenera). In accord with this tendency, it is here proposed to isolate the forms with five primary external lobes, three internal lobes, and no lobes on the umbilical walls under the name *Pseudoparalegoceras*. *Gastrioceras russiense*, the first representative of the group known, is designated as the genotype of *Pseudoparalegoceras*. It was originally described by Tzwetaev[7] and the nature of its sutures was later elucidated by Karpinsky.[8] As far as is now known

[4] Established by Foord, A. H., and Crick, G. C., Catalogue of the fossil Cephalopoda in the British Museum, pt. 3, p. 226, 1897.

[5] Karpinsky, A., Über die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische Formen: *Mém. l'Acad. Imp. des Sci. de St.-Pétersbourg*, VIIe série, t. 37, no. 2, p. 47, 1889.

[6] Hyatt, Alpheus, Carboniferous cephalopods: *Texas Geol. Survey, Ann. Rept.* 2, p. 355, 1891.

[7] Tzwetaev, Marie, Cephalopodes de la section supérieure du calcaire carbonifère de la Russie centrale: *Mém. du Comité Géol.*, vol. 5, no. 3, pp. 2–4, 42–44, pl. 6, figs. 30–32, 1888.

[8] *Op. cit.*

the new genus includes only the two species mentioned and is confined to the Upper Carboniferous of central Russia and Peru.

Many of the forms now generally referred to *Gastrioceras* seem to be more closely related to *Goniatites* s. s., of which *Glyphioceras* is a synonym. The genotype of *Goniatites* is *G. sphaericus* (Martin) of the Lower Carboniferous of England and possibly Belgium, Germany, and Arkansas. The genotype[9] of *Glyphioceras* is *Goniatites crenistria* Phillips of the Lower Carboniferous of England and possibly Belgium, Germany, Arkansas, Texas, and Oklahoma. These two genotypes are so similar that many authors have considered them conspecific, and certainly they should not be referred to different genera or subgenera; since *Goniatites* has priority, it is to be retained and *Glyphioceras* is to be suppressed. In the genotype of *Goniatites* each of the complete sutures possesses a total of eight primary lobes, as in the genotype of *Gastrioceras*, but the conch is much more nearly globular in shape, the whorls are only slightly depressed dorso-ventrally and are crescentic rather than trapezoidal in cross-section, the umbilicus is very much smaller as the conch is much more deeply involute, and the umbilical borders are smooth and are not marked by prominent nodes or short ribs. Since the generic name *Glyphioceras* is to be suppressed as a synonym of *Goniatites*, the family name Glyphioceratidae also must be suppressed in favor of Goniatitidae; all of the genera discussed in this paper belong in this family.

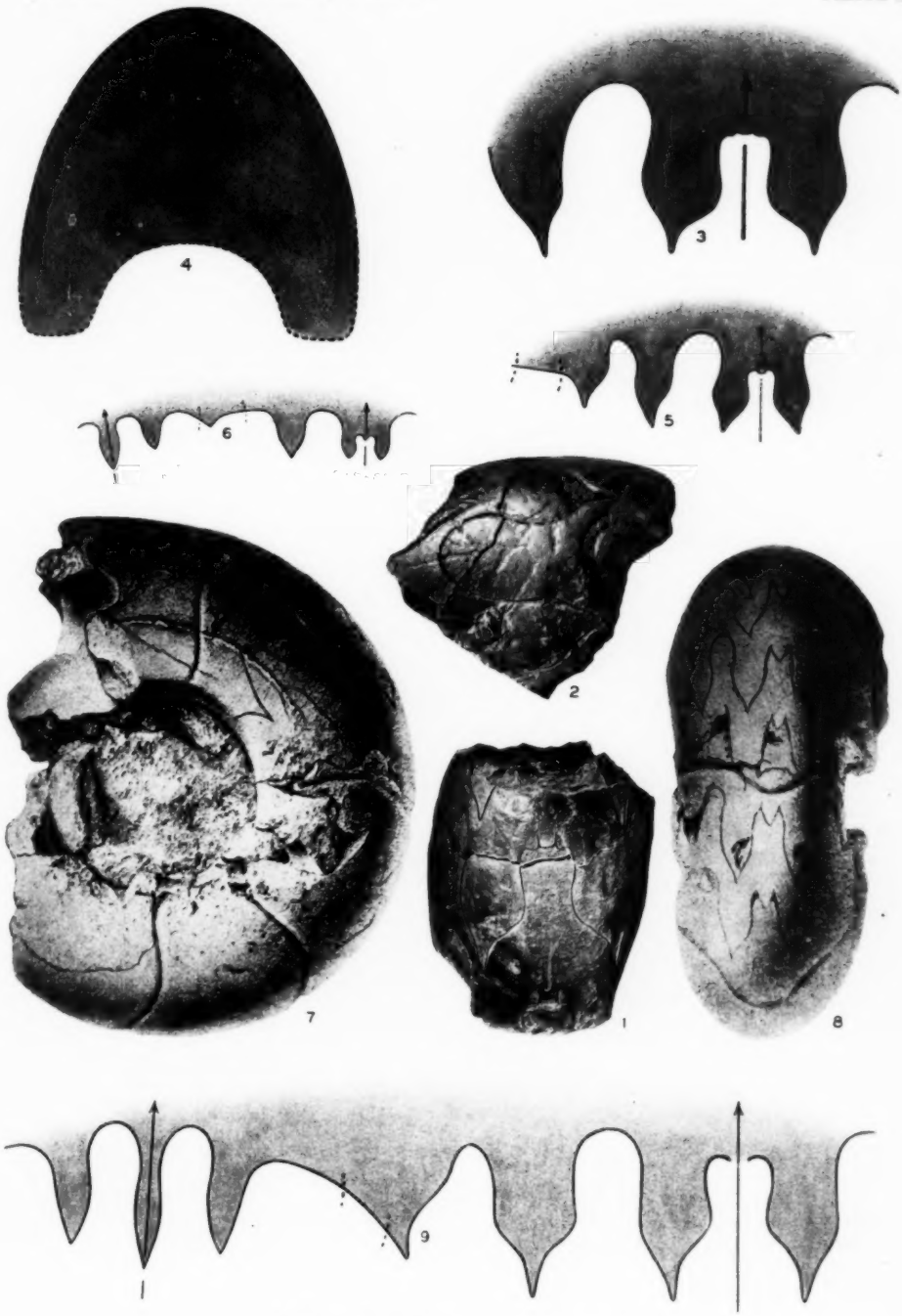
[9] Established by Foord and Crick, *op. cit.*, p. 154.

EXPLANATION OF PLATE 2

FIGS. 1–5—*Pseudoparalegoceras peruvianum* (Berry). 1, 2, Ventral and lateral views of the holotype, which came from the Upper Carboniferous of northwestern Peru ×1. 3, 4, Diagrammatic representation of a suture and diagrammatic restoration of cross-section of conch of same specimen as the preceding, ×1. 5, Diagrammatic representation of a suture of a topotype, ×1 (adapted from Thomas). [Berry's representation of the sutures of the holotype, published in 1928, though stated to be natural size, was inadvertentiy reduced in the printing.]

6—*Gastrioceras listeri* (Martin), the genotype of *Gastrioceras*. Diagrammatic representation of a suture of a small specimen, ×4. [Based on a specimen from the Lower Coal Measures of Shoe Mill Clough, near Accrington, Lancashire, England, in the paleontological collections of the State University of Iowa (Catalogue No. 625)].

7–9—*Pseudoparalegoceras russiense* (Tzwetaev). 7, 8, Lateral and ventral views of the holotype, which came from the Upper Carboniferous of central Russia, ×1 (after Tzwetaev). 9, Diagrammatic representation of a suture, ×1 (adapted from Karpinsky).



Miller, Carboniferous ammonoids

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 1, PP. 21–28, PLS. 3–4, MARCH, 1934

OLIGOCENE ORBITOIDS FROM NEAR DUNCAN CHURCH, WASHINGTON COUNTY, FLORIDA[1]

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ABSTRACT

The geological map of Florida issued in 1929 shows a small outcrop of Ocala limestone (Eocene) about 6 miles southwest of Chipley within the general area mapped as Glendon limestone (Oligocene). Detailed studies of the orbitoids from this area have proved that the rocks mapped as Ocala are really Glendon. The following species were found: *Lepidocyclina* (*Lepidocyclina*) *supera* (Conrad), *L.* (*L.*) *yurnagunensis* Cushman and its variety *morganopsis* Vaughan, *L.* (*Eulepidina*) *favosa* Cushman, *L.* (*E.*) *undosa* Cushman and its variety *tumida* Vaughan and *L. gigas* Cushman var. *duncanensis* n. var. These species and their varieties are not known to occur in the Eocene, but they are characteristic of the Oligocene, especially the middle Oligocene. Several of the forms have not been previously reported from the United States. Their discovery is of importance since it suggests a correlation of certain Oligocene formations of the Antillean and Mexican areas with the known column of the United States.

Cooke and Mossom[2] in discussing the Ocala limestone of Florida state:

> The only known outcrops of the Ocala limestone in Washington County are in the vicinity of Duncan. Thirty feet of white to cream-colored, soft limestone containing many orbitoid foraminifera is exposed in a large sink near Duncan Church, 7 miles southwest of Chipley. Rock for chimneys and tombstones has been quarried from the sink. There are at least two other quarries not far away, in sec. 36, T. 4 N., R. 14 W.

In 1932, Mr. Gerald M. Ponton of the Florida State Geological Survey sent samples from the Duncan Church locality and from a sink on the A. L. Parrish farm, 3½ miles southeast of Wausau, Washington County, Florida, to Dr. T. Wayland Vaughan. Upon examination of these samples, Dr. Vaughan expressed the opinion that the exposures represented by the samples were not of Eocene age but should be correlated with the Glendon formation of middle Oligocene age. Dr. Vaughan wrote:[3]

> With reference to the second collection, namely the one from near Duncan church, Washington County, Florida. A common species in that collection is one to which Cushman applied the name *Lepidocyclina chattahoochee-ensis*, which as you know I am now placing in the synonomy of *Lepidocyclina favosa* Cushman, the type of which came from the island of Antigua. The species is widely distributed in the West Indies, eastern Mexico, and the southeastern Gulf States. Of this species there are in the collection both microspheric and megalospheric individuals. It belongs to the subgenus *Eulepidina* which has not yet been

[1] Published with permission of the Florida State Geological Survey, Herman Gunter, State Geologist, Tallahassee.

[2] *Florida Geol. Survey*, 20th Ann. Rept., p. 61.

[3] Letter to Mr. Herman Gunter, Aug. 4, 1932.

found in the American Tertiary deposits older than middle Oligocene. In addition to the specimens that can be identified as *Lepidocyclina* (*Eulepidina*) *favosa* there are microspheric specimens of a rather large species which has a distinct umbo. These specimens seem to belong to the same species as the one that I have called *Lepidocyclina gigas* variety. I am in doubt as to whether these specimens really represent *L. gigas*. But they are certainly the same as specimens that I have so designated. Another lot represents specimens between 20–25 mm. in diameter. The umbo in these is virtually obsolete. It looks as if they graded into the form with the more pronounced umbo. I am not sure regarding a name for these specimens. Without rather long study of a very large collection I should hesitate to apply a name. Besides the larger specimens there are smaller, thin, flattish specimens and some more or less saddle-shaped specimens which attain a diameter of about 6 mm. These specimens belong to the subgenus *Lepidocyclina* proper. They may be the megalospheric form of the same species as that to which the nonumbonate microspheric form above mentioned belong. The geologic age of the material from near Duncan church is, I think, Glendon, that is middle Oligocene.

The third collection, sink on A. L. Parrish farm, 3½ miles southeast of Wausau, Washington County, Florida, contains poorly-preserved specimens, but I think that a definite opinion as to the geologic age is justified. One specimen undoubtedly represents the same species as Cushman's *L. chattahoocheensis* and another is clearly the one which I have been calling *L. gigas* var. Other specimens seem to represent the same species as the smaller, thin, flattish or saddle-shaped megalospheric specimens found near Duncan Church. Therefore, I have no hesitancy in expressing the opinion that this material is also Glendon, middle Oligocene age.

As Dr. Vaughan was at the point of leaving for a trip around the world, he suggested to Mr. Gunter that the material be turned over to the writer for detailed study. The writer wishes to acknowledge his indebtedness to Dr. Vaughan for this assignment and for the privilege of using an unpublished manuscript written by him entitled "Studies of American species of *Lepidocyclina*." The writer had the honor of assisting Dr. Vaughan in the final preparation of this manuscript during the past summer.

Cooke and Mossom apparently based their determination of the Eocene age of the rocks around Duncan Church upon the identification by Cushman of orbitoids from station 4974, 6 miles southwest of Chipley, on the west side of St. Andrews Bay road, collected by G. C. Matson. Cushman lists from this locality *Lepidocyclina attenuata*, *L. floridana*, and *L. ocalana* var. *subdecorata*. As

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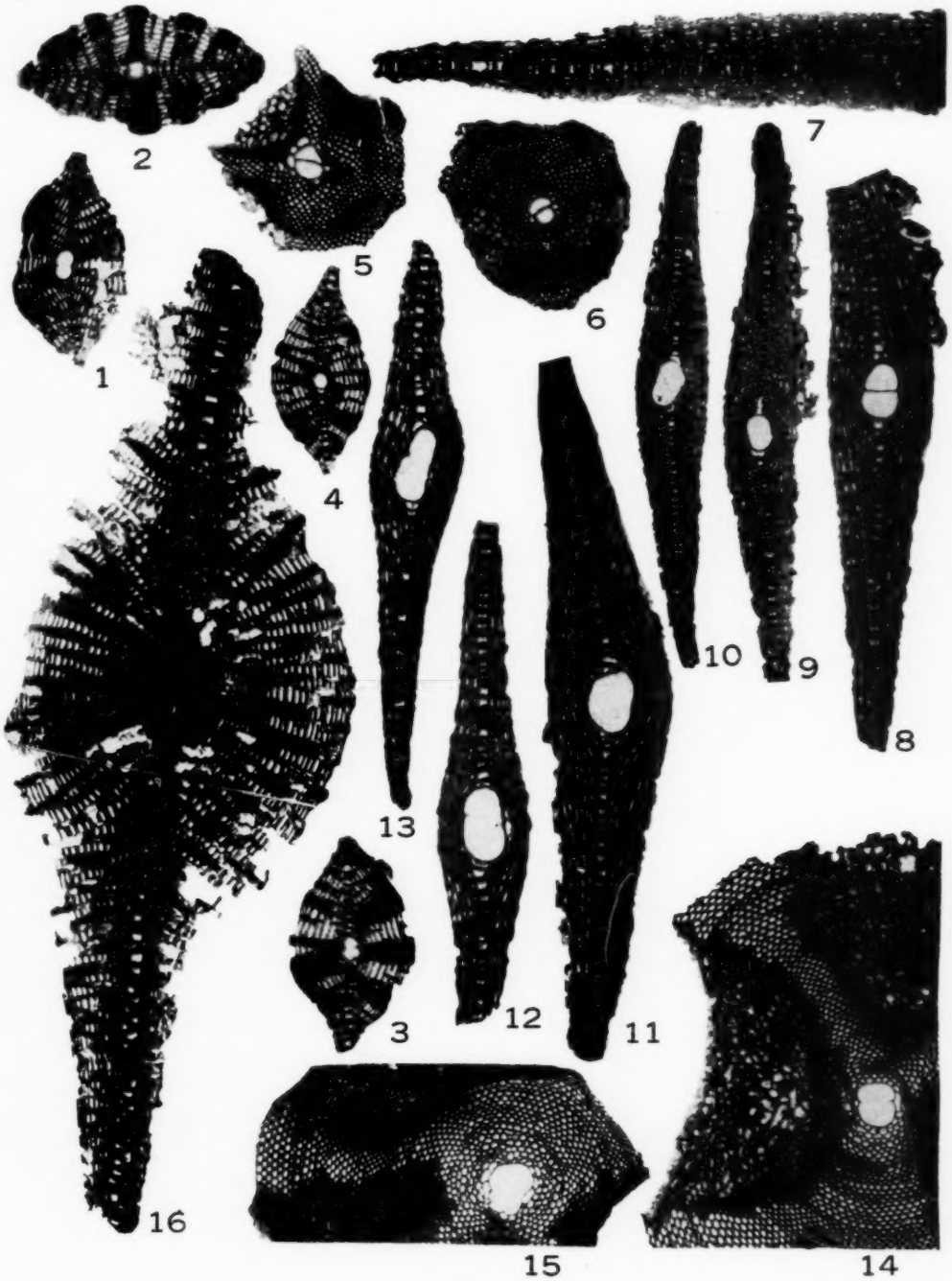
EXPLANATION OF PLATE 3

FIGS. 1–3—*Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman var. *morganopsis* Vaughan, vertical sections showing the development of the heavy pillars, ×15.
4—*Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman, vertical section, ×15.
5, 6—*Lepidocyclina* (*Lepidocyclina*) *yurnagunensis* Cushman, horizontal sections showing the diamond-shaped equatorial chambers and the variation in the shape of the embryonic chambers, ×15.
7–13—*Lepidocyclina* (*Lepidocyclina*) *supera* (Conrad), vertical sections, figure 7 represents a section of a microspheric individual. The other figures represent sections of megalospheric individuals introduced to show the variations between different individuals. ×10.
14, 15—*Lepidocyclina* (*Lepidocyclina*) *supera* (Conrad), horizontal sections, ×10.
16—*Lepidocyclina gigas* Cushman var. *duncanensis* Cole, n. var., vertical section of a microspheric individual, ×10, cotype.



Cole, Oligocene orbitoids

UNIV. OF MICH.

these species are confined to the Eocene, their conclusion was warranted. The original material studied by Cushman has not been available in the preparation of this paper. Mr. Ponton, who is acquainted with this area, has assured the writer, however, that the samples sent to Dr. Cushman represent the same horizon as that exposed over the entire patch 6 to 7 miles southwest of Chipley, mapped as Eocene by Cooke and Mossom.

Detailed study of the samples sent to the writer from this area has led to identification of the following species and varieties: *Lepidocyclina* (*Lepidocyclina*) *supera* (Conrad), *L.* (*L.*) *yurnagunensis* Cushman, *L.* (*L.*) *yurnagunensis* Cushman var *morganopsis* Vaughan, *L.*(*Eulepidina*) *undosa* Cushman, *L.* (*E.*) *undosa* Cushman var. *tumida* Vaughan, *L.* (*E.*) *favosa* Cushman, *Lepidocyclina gigas* Cushman var. *duncanensis* Cole, n. var. All of these are confined to the Oligocene and most of them have been found only in the middle Oligocene. Vaughan[4] reports forms similar to *L. supera* and *L. favosa* from the Alazan shale of eastern Mexico. If the Alazan shale is lower Oligocene, the vertical range of these two species will be extended, as they have been heretofore reported from only the middle or upper portion of the Oligocene section.

The detailed analysis of the fauna confirms Dr. Vaughan's opinion as expressed in the letter to Mr. Gunter, that the age of the limestone around Duncan, Washington County, Florida, is Glendon, middle Oligocene. There is thus no evidence of Eocene in this locality as indicated by Cooke and Mossom, but instead the rocks underlying this entire area are of the same age, that is, Glendon. The possibility of a local structure in this area is also destroyed as a result of this determination.

The fauna represented at the Duncan Church locality is practically identical with faunas which have been previously reported from Antigua, Jamaica, Cayman Brac, eastern Cuba, the State of Vera Cruz in Mexico and at other localities in the Caribbean and Gulf of Mexico region. The exact placing of the Duncan Church fauna in the Glendon formation of the Gulf Coastal Plain section of the United States is extremely important because of the bearing it will have on the correlation of these other localities, inasmuch as this is the first report of the occurrence of this fauna within the United States.

The writer wishes to express appreciation to Dr. T. Wayland Vaughan for reading this paper and making suggestions.

DESCRIPTION OF SPECIES

LEPIDOCYCLINA (LEPIDOCYCLINA) SUPERA (Conrad)

Plate 3, figures 7–15; Plate 4, figures 6, 7

Orbitolites supera CONRAD. *1865*, Acad. Nat. Sci. Philadelphia, Proc., no. 2, p. 74.
Orbitoides supera CONRAD, *1867*, Am. Jour. Sci., 2d. ser., vol. 43, p. 31.
Lepidocyclina supera H. DOUVILLÉ, *1918*, Compt. Rend., pp. 263, 264, figs. 6–8, 11.

[4] Vaughan, T. W., Studies in American species of *Lepidocyclina*. This paper has been recently published in the *Smithsonian Miscellaneous Collections*, vol. 89, no. 10, pp. 1–53, 32 pls., 1933.

Lepidocyclina supera CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125, p. 69, pl. 26 figs. 5–7.
Isolepidina supera H. DOUVILLÉ, *1924*, Soc. Géol. France, mém. n.s., vol. 1, mém. 2, p. 40, pl. 1, figs. 9, 10. text-figs. 23–26.
Lepidocyclina (Lepidocyclina) supera VAUGHAN, *1924*, Geol. Soc. Amer., Bull., vol. 35, pp. 797, 819, pl. 33, fig. 3.
Lepidocyclina (Lepidocyclina) supera VAUGHAN, *1927*, U. S. Nat. Mus., Proc. no. 2680, vol. 71, art. 8, p. 4, pl. 3, fig. 3.

This species is characterized by the possession of lateral chambers which are low and decidedly irregular in shape and size with the walls between successive layers varying greatly in thickness. Pillars are present and are well developed. Numerous specimens in the Florida material possess the above characteristics.

Species closely related to *L. supera* are *L. mantelli* (Morton), *L. miraflorensis* Vaughan, *L. forresti* Vaughan and *L. waylandvaughani* Cole. All of these species belong to *Lepidocyclina* s.s., which has two equal or subequal embryonic chambers, and all five have hexagonal equatorial chambers. *L. mantelli* is a larger species and has longer lateral chambers; *L. miraflorensis* has the lateral chambers developed in rather regular tiers with thin walls between; *L. forresti* lacks pillars, except a few weak ones in the central portion and *L. waylandvaughani* has its lateral chambers rather regularly developed with normally rather strong pillars. In *L. waylandvaughani* the equatorial chambers increase considerably in height as the margin is approached.

L. supera is the lepidocycline form referred to by Dr. Vaughan in his letter. Both megalospheric and microspheric forms are present in the material examined.

Localities and geologic horizons.—This species is found in the Byram marl, uppermost Oligocene of Mississippi, Alabama and Florida. It has been also reported from the Glendon formation of Mississippi. In Dr. Vaughan's manuscript in my possession he reports this species from the Alazan formation (considered to-date lower Oligocene) of Mexico.

LEPIDOCYCLINA (LEPIDOCYCLINA) YURNAGUNENSIS Cushman

Plate 3, figures 4–6; Plate 4, figures 8, 9

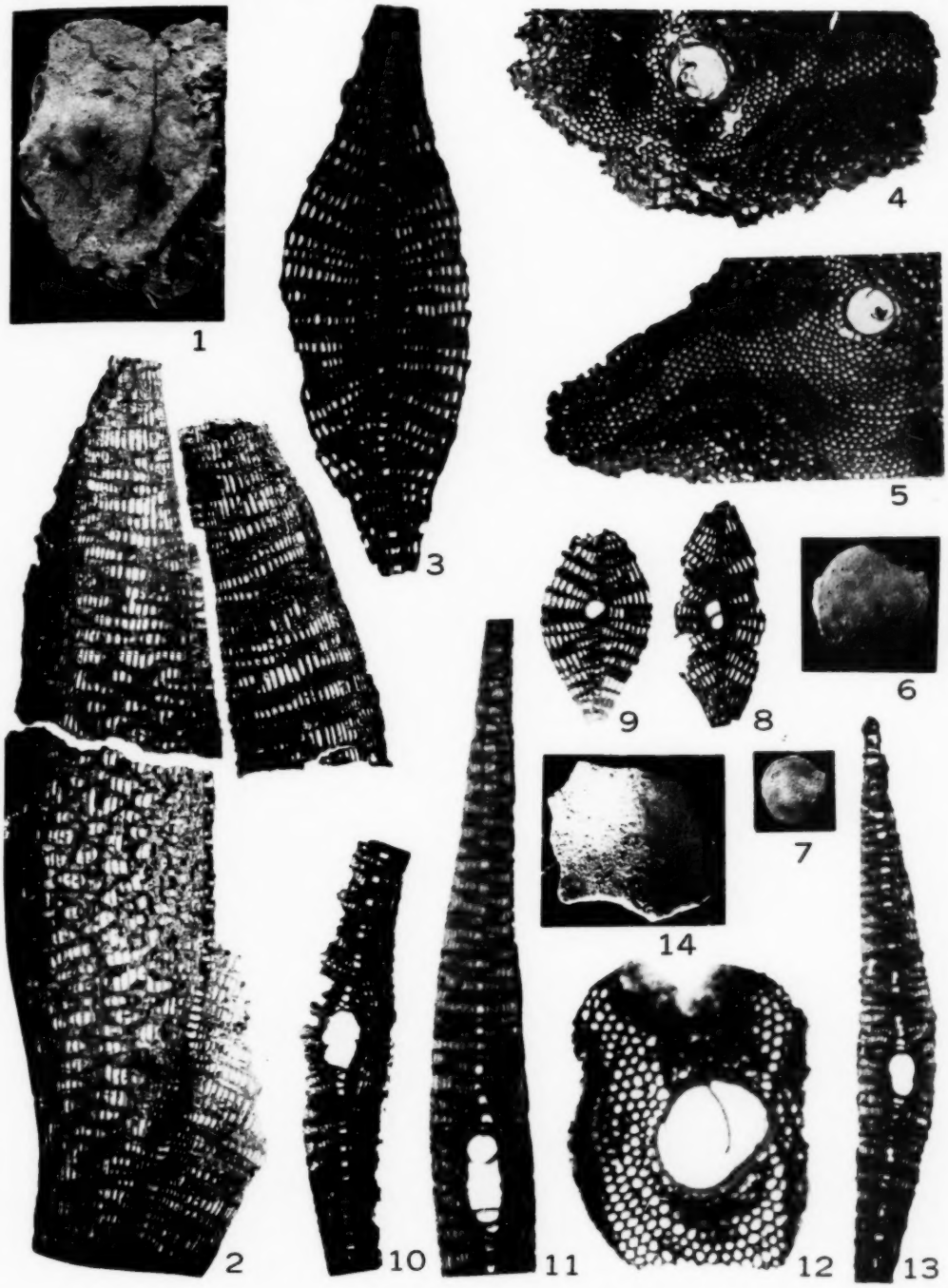
Lepidocyclina canellei var. *yurnagunensis* CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 57, pl. 12, figs. 7–8, text-fig. 6.
Lepidocyclina yurnagunensis VAUGHAN, *1926*, Geol. Soc. London, Quart. Jour., vol. 82, p. 391, pl. 25, figs. 2–6 (References and synonomy).

Since Vaughan has excellently and fully described this species[5] only notes on the Florida forms need be given here. The Florida representatives are in every respect typical. As already indicated by both Vaughan and Cushman, the embryonic chambers of *L. yurnagunensis* vary

[5] Species of *Lepidocylina* and *Carpenteria* from the Cayman Islands, and their geological significance: *Geol. Soc. London, Quart. Jour.*, vol. 82, pp. 388–400, 3 pls.

EXPLANATION OF PLATE 4

FIGS. 1—*Lepidocyclina gigas* Cushman var. *duncanensis* Cole, n. var., external view, ×1.5, cotype.
2, 3—*Lepidocyclina (Eulepidina) favosa* Cushman. Vertical sections of microspheric individuals, the section which is illustrated by figure 2 was broken into three pieces in grinding. Figure 2, ×10; figure 3, ×15.
4, 5—*Lepidocyclina (Eulepidina) undosa* Cushman, horizontal sections, showing the eulepidine embryonic chambers, ×10.
6, 7—*Lepidocyclina (Lepidocyclina) supera* (Conrad), external views; figure 7 shows the development of the surface papillae, ×1.5.
8, 9—*Lepidocyclina (Lepidocyclina) yurnagunensis* Cushman, vertical sections, ×15.
10, 11, 13—*Lepidocyclina (Eulepidina) undosa* Cushman; vertical sections of megalospheric individuals. Figures 10, 13, ×10; figure 11, ×15.
12—*Lepidocyclina (Eulepidina) favosa* Cushman, horizontal section of a megalospheric individual, ×15.
14—*Lepidocyclina (Eulepidina) undosa* Cushman, external view, ×1.5.



Cole, Oligocene orbitoids

from *Lepidocyclina* s.s. to *Nephrolepidina*. This variation is indicated in the Florida specimens by figures 5 and 6 of Plate 3. The equatorial chambers are predominantly diamond or lozenge-shaped. The pillars are weakly developed.

This species was not noted in the original collection examined by Dr. Vaughan, but was found in subsequent collections from the same locality sent to the writer.

Localities and geologic occurrence.—The type locality is U. S. Geol. Survey. Loc. 7548, the west side of the Yateras River, about $2\frac{1}{2}$ miles south of Yuraguana, about 2 miles north of ElJique, near Guantánamo, Cuba, collected by O. E. Meinzer. It is found in the limestone on Cayman Brac, Cayman Islands, in the Antigua formation of Antigua and in the Moneague formation of Jamaica. It is generally associated with *L. favosa* Cushman and other middle Oligocene species. It is apparently a rather common species with a wide geographic distribution in the Antillean region. This is the first report of its occurrence in the United States.

LEPIDOCYCLINA (LEPIDOCYCLINA) YURNAGUNENSIS var. MORGANOPSIS Vaughan

Plate 3, figures 1–3

Lepidocyclina yurnagunensis var. *morganopsis* VAUGHAN, *1933*, Jour. Wash. Acad. Sci., vol. 23, no. 7, p. 354.

Specimens referred by Cushman to *Lepidocyclina morgani*[6] Lemoine and R. Douvillé are considered by Vaughan to represent a variety of *L. yurnagunensis*. The equatorial section of this variety shows the same characters of both embryonic and equatorial chambers as do equatorial sections of the typical. The vertical sections of the variety, however, show strongly developed pillars whose distal ends form the large surface pustules.

[6] Cushman, J. A., *Carnegie Inst. Washington, Pub.* 291, p. 59, pl. 11, figs. 1–3, text. fig. 7, 1919; *U. S. Geol. Survey, Prof. Paper* 125, p. 74, pl. 33, figs. 12–14, 1920.

Although Vaughan briefly defines this variety in the paper referred to above, the complete discussion is contained in his manuscript entitled "Studies of American species of *Lepidocyclina*." Since Vaughan's paper will probably not appear as soon as this one, the writer is presenting Cushman's description of the specimens which he refers to *L. morgani* and Vaughan's comments on his variety from his manuscript.

Cushman's description is as follows:

Test small, discoidal, much thickened in the central portion, from which it tapers rather rapidly to the subacute periphery; central protuberant portion with a series of large pustules ranging from 5 to 12 or more in number, of which one is usually central, surface reticulate between the pustules; the margin stellate; periphery of the test thin and slightly reticulate by the walls of the equatorial chambers.

Vertical sections show the general form and curvature of the surface of the test, the few pillars in the central region rapidly increasing in diameter toward the surface of the test; lateral chambers in the outer wall convex, averaging about three times as wide as high; in the central region with as many as 10 chambers in the vertical columns; equatorial chambers not increasing rapidly in height; height of those at the periphery not more than double that of those near the center.

Horizontal sections show the embryonic chambers which are unequal, the larger one partially surrounding the smaller, as in the subgenus *Nephrolepidina* of H. Douvillé and the equatorial chambers more or less diamond-shaped, as in that subgenus. In other specimens the outer wall of the chamber is convex. Diameter 2 to 5 mm.

Vaughan's comments on his new variety are as follows:

A locality at which the form is abundant in U. S. Geol. Survey no. 7552, just south of El Jique, about 6 miles above the mouth of Yateras River, altitude about 250 feet, collected by O. E. Meinzer. The specimens of both *L.*

yurnagunensis and *L. yurnagunensis* var. *morganopsis* from this locality are very good.

Doctor Cushman's figure of the embryonic chambers of a specimen identified by him as *L. morgani* should be compared with his figure (1920, pl. 33, figs 4–9) of the embryonic chambers of *L. yurnagunensis*. The similarity is obvious. The embryonic chambers of *L. yurnagunensis* vary from *Lepidocyclina* s.s. to *Nephrolepidina*, and some are almost *Pliolepidina*, as Cushman has shown. The embryonic and equatorial chambers of *L. yurnagunensis* var. *morganopsis* are similar to those of typical *L. yurnagunensis*, from which the variety differs solely by its more greatly developed pillars which terminate in pustules on the surface.

Cotypes.—Locality 7543, two thin sections and a few uncut specimens, U. S. National Museum.

The Florida specimens are in every respect typical of this variety as defined by Vaughan. It is fairly abundant in the samples and can be recognized readily both by its external appearance and in vertical sections. As Vaughan has indicated, horizontal sections of the variety are in every respect identical to those of *L. yurnagunensis*.

LEPIDOCYCLINA (EULEPIDINA) UNDOSA Cushman

Plate 4, figures 4, 5, 10, 11, 13, 14

Lepidocyclina undosa CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 65, pl. 2, fig. 1 *a*.

Lepidocyclina undosa CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125, p. 68 pl. 25, fig. 3.

Lepidocyclina (Nephrolepidina) undosa VAUGHAN, *1924*, Geol. Soc. America, Bull., vol. 35, pp. 798, 820, pl. 34, figs. 5–7.

Lepidocyclina (Nephrolepidina) undosa VAUGHAN, *1926*, Geol. Soc. London, Quart. Jour., vol. 82, p. 393–395, pl. 24, figs. 1, 2.

Lepidocyclina (Nephrolepidina) undosa VAUGHAN, *1928*, Jour. Paleontology, vol. 1, no. 4, pp. 294, 295, pl. 48, fig. 3.

Lepidocyclina (Nephrolepidina) undosa COLE and GILLESPIE, *1930*, Bull. Am. Paleontology, vol. 15, no. 57 *b*, p. 3, pl. 1, figs. 1, 2.

Lepidocyclina (Eulepidina) undosa GORTER and VAN DER VLERK, *1932*, Leidsche Geol. Med., Deel 4, Aflev. 2, p. 110, pl. 15, figs. 1–4.

This species is rather easily determined because of its pronounced internal and external features. Cushman has published satisfactory external views and Vaughan in several of his papers has given excellent sections illustrating the internal features of this species. The Florida specimens are in every respect typical.

The embryonic apparatus in all equatorial sections examined are of decided eulepidine type. Vaughan has stated in his papers that the embryonic chambers of this species grade from nephrolepidine to eulepidine. The eulepidine type is very characteristic of the Mexican specimens referred to this species. Equatorial sections of Mexican specimens showing this type of embryonic apparatus have been published by Vaughan and by Cole and Gillespie.

Some of the specimens in the Florida material referred to this species are not as strongly selliform as are many specimens from other localities. There are all degrees of gradation, however. The less strongly selliform types in this material generally have a rather pronounced umbo, at least, on one side. There is a gradation from this type to forms which Vaughan designated variety *tumida*. As there is a gradational series, it seems only desirable to designate the typical and the extreme tumid variety.

This species is not as abundant in the Florida material as other species. Specimens referable to it were not present in the original collection studied by Dr. Vaughan.

Localities and geologic occurrence.—This is a common and widely distributed species in the middle Oligocene of the Caribbean and Gulf region. The type specimens were collected in Long Island, just off the northeastern shore of Antigua at U. S. Geol. Survey locality 6869. It occurs in the Antigua formation of Antigua, in the limestone on Cayman Brac, Cayman Islands, in the Moneague formation of Jamaica, in the Meson formation of Mexico and in the Glendon formation of Alabama.

LEPIDOCYCLINA (EULEPIDINA) FAVOSA Cushman

Plate 4, figures 2, 3, 12

Lepidocyclina favosa CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 66, pl. 3, figs. 1, 2, pl. 15, fig. 4.
Lepidocyclina crassata CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, pp. 61, 62, pl. 11, figs. 4, 5.
Lepidocyclina chattahoocheensis CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 125, p. 65, pl. 23, figs. 1–4, pl. 24, figs. 1, 2.
Lepidocyclina (Nephrolepidina) crassata VAUGHAN, *1924*, Geol. Soc. America, Bull., vol. 35, p. 798, pl. 34, figs. 3, 4.
Lepidocyclina (Nephrolepidina) chattahoocheensis VAUGHAN, *1924*, Geol. Soc. America, Bull., vol. 35, p. 798, pl. 34, fig. 2.
Lepidocyclina (Eulepidina) formosa VAUGHAN, *1924*, Geol. Soc. America, Bull., vol. 35, p. 799 (*not* Schlumberger).
Lepidocyclina (Eulepidina) favosa VAUGHAN, *1924*, Geol. Soc. America, Bull., vol. 35, p. 799, pl. 34, fig. 8.
Lepidocyclina (Eulepidina) formosa VAUGHAN, *1926*, Geol. Soc. London, Quart. Jour., vol. 82, p. 395 (*not* Schlumberger).

Vaughan has recently published[7] remarks concerning the relationship of certain species which he is now grouping under the specific name *favosa*. The above synonomy, however, is copied directly from Dr. Vaughan's manuscript. Full discussion and the reasons for placing these species in synonomy under *L. favosa*, will have to await publication of Dr. Vaughan's paper.

Specimens referred to *L. favosa* are fairly common in the material examined. Horizontal sections and vertical sections are figured for reference with other published figures of this form. Horizontal sections resemble very close those of *Lepidocyclina (Eulepidina) undosa* as *L. undosa* in this material has embryonic chambers which are more nearly *Eulepidina* than they are *Nephrolepidina*. This feature seems to characterize the Mexican specimens of *L. undosa*, also. Externally and in vertical sections the specimens referred to *L. favosa* in this material are greatly different in appearance from those referred to *L. undosa*.

[7] Vaughan, T. W., *Jour. Washington Acad. Sci.*, vol. 23, no. 7, p. 354, 1933.

Localities and geologic occurrence.—This species has been reported in the middle Oligocene Glendon formation in Georgia, Florida and Alabama; in the Meson formation of Mexico; in the Antigua formation of Antigua; at many places in the Oligocene of eastern Cuba. It has generally been assumed to be confined to the middle Oligocene, but Dr. Vaughan notes in his manuscript that a form very similar to *L. favosa* was collected by him from the Alazan shale at the crossing of the Alazan-Moyutta road over the Rio Buena Vista. The Alazan shale has been generally considered lower Oligocene in age.

LEPIDOCYCLINA GIGAS Cushman var. DUNCANENSIS Cole, n. var.

Plate 3, figure 16; Plate 4, figure 1

Lepidocyclina gigas VAUGHAN var., *1928*, Jour. Paleontology, vol. 1, no. 4, p. 295.

The variety differs from the typical species in its smaller size, in being relatively thinner, in possessing relatively longer lateral chambers which are not so regular in their development and in having weaker and more irregularly developed pillars.

The specimen referred to this variety had a semidiameter of 15 mm., the diameter, therefore, exceeds 30 mm. as the edge is apparently broken. The section figured was cut from a specimen 14 mm. in diameter but this probably represents only a portion of the total diameter of the original specimen as the outer border was apparently missing. The thickness of this specimen in the tumid, umbonate portion is about 5 mm. Another specimen with a diameter exceeding 20 mm. has a thickness of 2.3 mm. at the center.

In view of the amazing variability shown in many species of *Lepidocyclina* the desirability of erecting varietal names may be questioned in the case of forms like this. It appears desirable at the present time to have names to designate certain variants of a given species. This problem was specifically treated by

Vaughan in his discussion of *L. ocalana* and its variants. The writer recognizes that other workers may not feel the use of varietal names justified in these cases.

The Florida specimens are similar to the forms designated by Vaughan as *L. gigas* var. from the Moneague formation of Jamaica. The Florida specimens were compared by Dr. Vaughan and the writer with specimens in the collection of Dr. Vaughan at Scripps Institution. The responsibility of erecting the varietal name rests solely with the writer, however.

Localities and geologic occurrence.—Typical *L. gigas* has been reported from many middle Oligocene localities in the Caribbean and Gulf region. As noted above a variety which appears to be identical with the Florida variety has been reported by Vaughan from many localities in the Moneague formation of Jamaica.

It is interesting to note that at practically every locality at which *L. gigas* or its variants are found, there occurs also forms referable to *L. undosa*. Vaughan has stated on several occasions that the *L. undosa-L. gigas* group represent a couple, with *L. undosa* the megalospheric and *L. gigas* the microspheric form. The writer feels that this is probably the correct relationship, but as there is still no definite proof the two names must be retained.

The specimens figured on plates 3 and 4 are all from the old quarry near Duncan Church, Washington County, Florida.

JOURNAL OF PALEONTOLOGY, VOL. 8, NO. 1, PP. 29–34, PL. 5, MARCH, 1934

THE OSTRACODE GENUS *CYTHERELLOIDEA* IN THE GULF COAST TERTIARY

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ABSTRACT

Twelve species and a variety of the ostracode genus *Cytherelloidea* are described from Eocene, Oligocene and Miocene rocks of the Gulf Coast. All are thought to be new, and all are short in range and make excellent guide fossils.

The genus *Cytherelloidea* was proposed by C. I. Alexander[1] to include a number of highly ornamented ostracodes which had commonly been placed in *Cytherella* but which differ from that genus in having an ornamented surface and in the fact that the right valve, while larger, does not overlap the left valve around the entire periphery as is the case in *Cytherella*.

The writer has found *Cytherelloidea* to be commonly represented in the Tertiary of the Gulf Coast and interest aroused by Alexander's excellent paper caused him to examine critically the forms present in the different formations. The immediate result was to discover that the pattern of ornamentation was sufficiently complex to record definite changes from formation to formation and yet simple enough to be recognized readily. Twelve species and a variety that are described in this paper the writer feels certain are of short range and will prove quite useful for definite correlation purposes.

[1] Alexander, C. I., *Texas Univ. Bull.* 2907, p. 55, 1929.

DESCRIPTION OF SPECIES

Family CYTHERELLIDAE

Genus CYTHERELLOIDEA Alexander, 1929

CYTHERELLOIDEA TOMBIGBEENSIS Howe, n.sp.

Plate 5, figure 8

Carapace in side view oblong, ovate. Valves flat with very shallow internal cavity. Dorsal margin highest at the anterior and posterior ends; slightly concave downward in the middle. Ventral margin faintly concave upward in the middle portion. Anterior and posterior ends rounded and subequal. A sharp narrow ridge starts slightly anterior and dorsal to the middle, continues backward and upward to the posterior-dorsal angle where it then follows down the posterior margin, around the ventral and anterior margins and dies out at the anterior-dorsal angle. There is a shallow, subcentral depression and between this depression and the ventral margin there is a short, sharp ridge which is concave upward but which disappears anteriorly and posteriorly before reaching the marginal rim. Right valve slightly larger than left, but bearing similar sculpture. Surface of the carapace otherwise smooth.

Length 0.45 mm.; height 0.27 mm.

The holotype of this species is described from the type locality of the Nanafalia division of the Sabine Eocene at Nanafalia Landing on the Tombigbee River, Alabama. Louisiana State Univ., Mus. No. 586.

CYTHERELLOIDEA TOMBIGBEENSIS var. DELICATA Howe, n.var.

A variety of the above species in the upper Midway of Alabama differs from the typical Nanafalia form in having a much broader and deeper central pit, in having the sharp ridge dorsal to the pit strongly arched upward, in having the posterior continuation of the ridge distinctly removed from the posterior end of the valve, and in having a much more elongate ridge below the central pit which is strongly hooked upward at the posterior end. The carapace is larger, more elongate and the sculpture in general is much more delicate.

Length 0.54 mm.; height 0.26 mm.

Holotype of the variety from the Midway Eocene Matthews Landing on the Alabama River, Alabama. Louisiana State Univ., Mus. No. 587.

CYTHERELLOIDEA NANAFALIENSIS Howe, n.sp.

Plate 5, figure 10

Carapace in side view oblong; thickest at the posterior end. Dorsal margin and ventral margin slightly sinuate. Anterior and posterior ends rounded. A small rounded pit is situated just dorsal to the middle of the valves. There are two faint longitudinal ridges which start at the thickened posterior margin; the lower ridge follows near the ventral margin almost to the anterior end; the upper ridge follows the center of the valve to a point anterior to the subcentral pit, where it tends to curve upward and then backward around the pit. Surface of the valves otherwise smooth and without a typical marginal rim.

Length 0.53 mm.; height 0.30 mm.

Holotype from the Nanafalia formation, Sabine Eocene at Nanafalia Landing on the Tombigbee River, Alabama. Louisiana State Univ., Mus. No. 588.

CYTHERELLOIDEA VEATCHIANA Howe, n.sp.

Plate 5, figure 4

Carapace in side view oblong. Dorsal and ventral margins straight and parallel. Anterior and posterior ends rounded, subequal. A sharp narrow ridge runs along the rounded anterior margin and continues faintly backward along the ventral margin dying out near the posterior end; the anterior marginal ridge ends abruptly dorsally at the anterior-dorsal angle. A high sharp ridge begins just below the anterior-dorsal angle and continues to the posterior-dorsal angle where it joins a slightly thickened swelling and turns abruptly downward to a point just above the posterior-ventral angle, where it again turns abruptly and continues slightly above the ventral margin to a point just above the anterior-ventral angle where it abruptly ends. Just dorsal to the middle of the valves there is a small rounded pit. Surface otherwise smooth.

Length 0.52 mm.; height 0.33 mm.

Holotype from the Nanafalia Eocene at Nanafalia Landing on the Tombigbee River, Alabama. The species is fairly common at this locality. Louisiana State Univ., Mus. No. 589. Named in honor of A. C. Veatch.

CYTHERELLOIDEA SMITHVILLENSIS Howe, n.sp.

Plate 5, figure 3

Carapace in side view oblong, subquandrangular. Valves flat with very shallow internal cavity. Dorsal margin gently arched posterior to the middle. Ventral margin straight throughout most of its length, but turned strongly downward at the posterior-ventral angle. Posterior end thick, sharply truncate. Anterior end rounded, thin. The upper half of the valve distinguished by an elongate

depression which is rounded at its anterior extremity and sharp at its posterior end and marked by a small subcircular pit just above the middle of the valve. The lower half of the valve is marked by an elongate subcrescentic depression which starts near the raised posterior, continues sinuously to the anterior quarter of the valve where it turns downward and follows the ventral margin back to the posterior-ventral angle. Surface otherwise smooth.

Length 0.56 mm.; height 0.29 mm.

Holotype from the Claiborne Eocene, Smithville, Bastrop County, Texas, in material kindly furnished the writer by Mr. Eli T. Monsour. Louisiana State Univ., Mus. No. 590.

CYTHERELLOIDEA BASTROPENSIS
Howe, n.sp.
Plate 5, figure 12

Carapace in side view subovate, highest near the anterior end. Dorsal margin convex upward; ventral margin nearly straight; anterior margin broadly rounded; posterior margin more acutely rounded and gently angled at the middle and again at the posterior ventral angle. A small depression occurs just above the middle, and two low rounded ribs start posterior and ventral to this depression, curve downward around it, continue toward the anterior end and die out before reaching it. Surface otherwise smooth.

Length 0.35 mm.; height 0.22 mm.

Holotype from the Claiborne Eocene of Smithville, Bastrop County, Texas, in material kindly furnished the writer by Mr. Eli. T. Monsour. Louisiana, State Univ., Mus. No. 591.

CYTHERELLOIDEA DANVILLENSIS
Howe, n.sp.
Plate 5, figure 5

Carapace in side view oblong, subquadrangular. Valves flat, with very shallow internal cavity. Dorsal and ventral margins straight, parallel. Anterior end evenly rounded. Posterior end obliquely rounded, subangular at the posterior-dorsal angle. A slightly raised ridge encircles the entire periphery, being highest and sharpest around the anterior end. A prominent pit lies just below the center of the dorsal margin. The pit tends to be bounded dorsally by a low ridge which is convex upward. and which tends at its ventral ends to join the elongate central ridge which bounds the pit on its ventral border. This subcentral ridge starts near the middle of the anterior third of the valve, bends gently downward below the pit and is then sharply curved upward posteriorly to the pit, dying out before reaching the marginal rim. Below the subcentral ridge there is a shorter, nearly straight rounded ridge which is bent upward slightly at its posterior extremity, but which at no place tends to join the marginal rim. Surface otherwise smooth.

Length 0.60 mm.; height 0.32 mm.

Holotype from the upper Jackson Eocene at Danville Landing on the Ouachita River, Louisiana, where it is exceedingly common. Louisiana State Univ., Mus. No. 592.

A variety of this species, common in nearly all marine lower Jackson localities, differs from this form in not having the low rounded hemicircular ridge above the pit. The writer believes this variant to be characteristic of the lower and middle Jackson, but the difference was so slight that a varietal name seemed hardly justified.

Among the localities where the variant has been observed by the writer are: Montgomery, Louisiana; Belhaven College at Jackson, Mississippi, and Grandview Bluff on the Ouachita River, Louisiana.

CYTHERELLOIDEA MONTGOMERYENSIS
Howe, n.sp.
Plate 5, figure 1

Carapace in side view oblong. Dorsal margin depressed anterior to center. Ventral margin nearly straight. Anterior margin evenly rounded. Posterior margin

rather elevated and truncate. A low marginal rim starts at the posterior-dorsal angle, follows the dorsal, anterior and ventral margins to the posterior-ventral angle; being highest and sharpest around the anterior end. A deep depression starts at the center of the valves and continues upward to the dorsal rim, thence gradually narrowing, follows just below the dorsal rim to the posterior-dorsal angle. A subcentral rounded ridge starts just above the middle of the high posterior border, turns obliquely downward to the center of the valve and then curves gently upward around the anterior-ventral margin of the pit, expanding rapidly as it passes the pit into a gently inflated area anterior to the pit. Another ridge starts below the middle of the raised posterior end and continues nearly straight above the ventral border almost to the anterior end where it dies out without reaching the anterior raised rim. Surface otherwise smooth.

Length 0.64 mm.; height 0.35 mm.

Holotype from the basal Jackson Eocene at Montgomery, Louisiana. This species is commonly present in the basal Jackson of Louisiana and Mississippi. Louisiana State Univ., Mus. No. 593.

CYTHERELLOIDEA OUACHITENSIS
Howe, n.sp.
Plate 5, figure 11

Carapace in side view oblong ovate. Dorsal margin depressed just anterior to the middle. Ventral margin straight. Anterior and posterior ends rounded, subequal. A sharp marginal rim starts at the anterior dorsal angle and continues around the anterior and ventral margins to the posterior-ventral angle. Two ribs start at somewhat thickened tubercles on the posterior margin; the lower follows just

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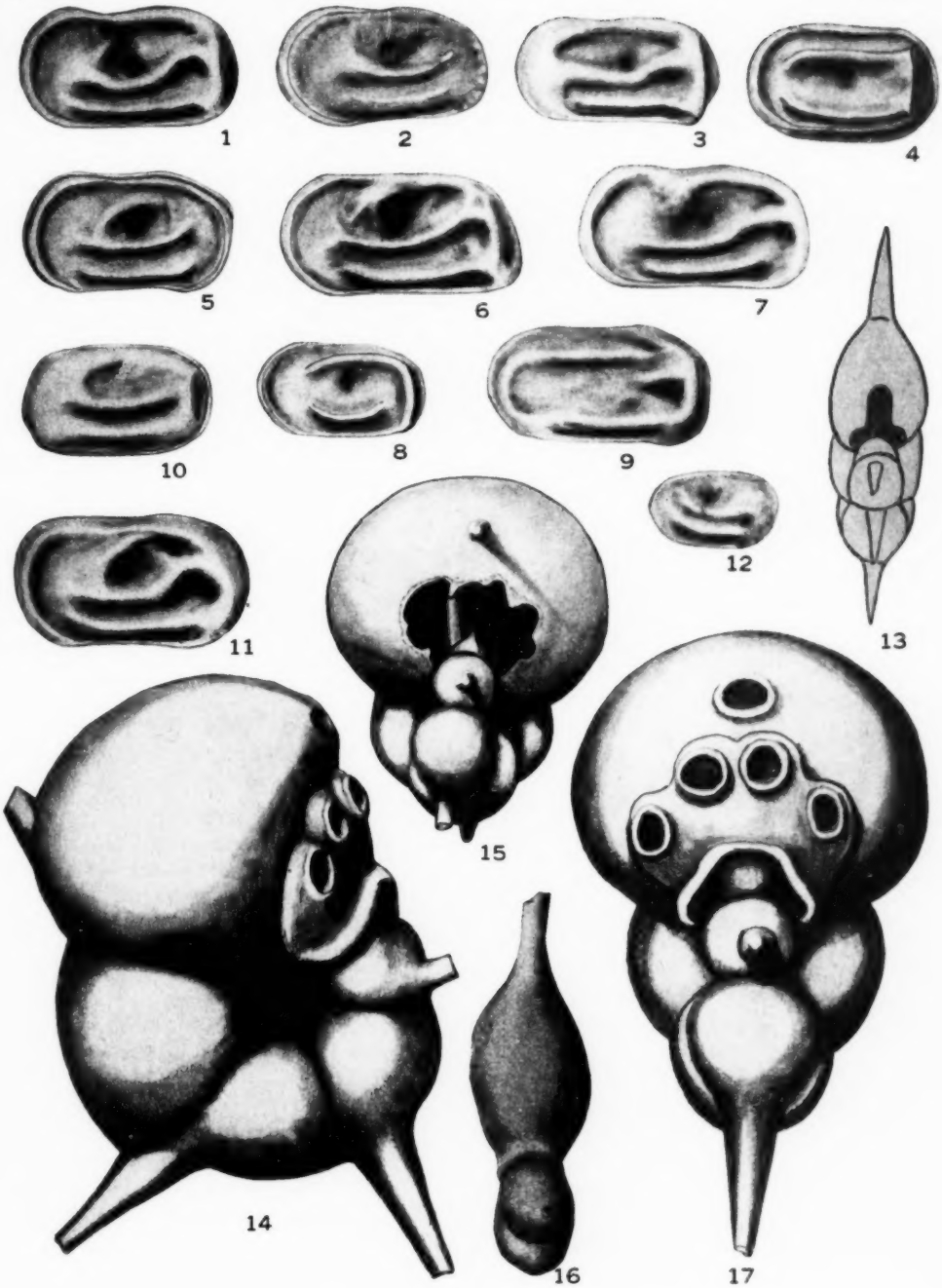
EXPLANATION OF PLATE 5

FIG. 1—*Cytherelloidea montgomeryensis* Howe, n. sp. From the basal Jackson at Montgomery, Louisiana.
2—*Cytherelloidea hiwanneensis* Howe, n. sp. From the Red Bluff Oligocene at Hiwannee, Mississippi.
3—*Cytherelloidea smithvillensis* Howe, n. sp. From the Claiborne at Smithville, Texas.
4—*Cytherelloidea veatchiana* Howe, n. sp. From the Sabine Eocene at Nanafalia Landing, Alabama.
5—*Cytherelloidea danvillensis* Howe, n. sp. From the upper Jackson at Danville Landing on the Ouachita River, Louisiana.
6—*Cytherelloidea vicksburgensis* Howe, n. sp. From the Vicksburg Oligocene at Vicksburg, Mississippi.
7—*Cytherelloidea alabamensis* Howe, n. sp. From the Oligocene limestone at Old Fort St. Stephens bluff on the Tombigbee River, Alabama.
8—*Cytherelloidea tombigbeensis* Howe, n. sp. From the Sabine Eocene at Nanafalia Landing on the Tombigbee River, Alabama.
9—*Cytherelloidea leonensis* Howe, n. sp. From the Choctawhatchee Miocene on Harveys Creek, Leon County, Florida.
10—*Cytherelloidea nanafaliensis* Howe, n. sp. From the Sabine Eocene at Nanafalia Landing, Alabama.
11—*Cytherelloidea ouachitensis* Howe, n. sp. From the upper Jackson at Danville Landing on the Ouachita River, Louisiana.
12—*Cytherelloidea bastropensis* Howe, n. sp. From the Claiborne at Smithville, Bastrop County, Texas.
13—*Hantkenina alabamensis* Cushman. After text figure in U. S. Nat. Mus., Proc., vol. 66, art. 30, 1924.
14—*Hantkenina danvillensis* Howe and Wallace, n. sp., ×128. Side view.
15—*Hantkenina mccordi* Howe and Wallace, ×64.
16—*Hantkenina multispinata* Cushman and Wickenden. After Cushman and Wickenden, Contr. Cushman Lab. Foram. Research, vol. 6, pt. 2, pl. 6, fig. 4*c*, 1930.
17—*Hantkenina danvillensis* Howe and Wallace, n. sp., ×128. Apertural view.

All figured holotypes are deposited in the type collection of the School of Geology, at Louisiana State University, Baton Rouge, Louisiana. Figures 1–12, about ×50.



Howe, Tertiary ostracodes
Howe and Wallace, Tertiary foraminifera

above the ventral marginal rim to the anterior quarter of the valve where it dies out. The upper rib is much more complex and upon reaching the subcentral pit branches and a fork follows up around the posterior margin of the pit almost to the dorsal rim; the main rib, however, continues down around the ventral border of the pit, again branching, with part of it dying out in the anterior quarter of the valve, while the other fork continues around the anterior side of the pit and joins the dorsal rim at the center of the dorsal margin. Surface otherwise smooth.

Length 0.68 mm.; height 0.38 mm.

Holotype from the upper Jackson Eocene Danville Landing on the Ouachita River, Louisiana, where it is very common. Louisiana State Univ., Mus. No. 594.

This species is clearly a direct descendant from *C. montgomeryensis*, but differs from it in having a much more rounded posterior end and in the manner in which the subcentral pit is almost completely surrounded by the branching of the upper rib.

CYTHERELLOIDEA HIWANNEENSIS
Howe, n.sp.
Plate 5, figure 2

Carapace in side view oblong, subquadrangular, highest near the anterior end. Dorsal and ventral margin straight or slightly sinuate. Anterior end broadly rounded. Posterior end narrower and subtruncate. A narrow marginal rim borders the periphery, being elevated and sharp around the anterior end, faint along the dorsal and ventral borders and more prominent and slightly beaded around the posterior end. Two low rounded ribs, which are curved downward in the middle of the valve, occupy the space in the middle of the valve below a broad shallow subcentral pit. The upper of the two ribs tends to develop a short spine at its posterior end. Surface otherwise smooth.

Length 0.58 mm.; height 0.34 mm.

Holotype from the Red Bluff Oligocene at Hiwannee, Mississippi. This species occurs sparingly from the bottom of the Vicksburg Oligocene to the Byram marl at Byram, Mississippi. Louisiana State Univ., Mus. No. 595.

CYTHERELLOIDEA ALABAMENSIS
Howe, n.sp.
Plate 5, figure 7

Carapace in side view oblong, dorsal and ventral margins slightly sinuate, subparallel. Anterior and posterior ends rounded. The entire periphery surrounded by a raised rim which becomes high and sharp around the anterior end. Two elongate rounded ribs lie below a subcentral pit; the dorsal rib joining the posterior margin, but the ventral rib stopping short of it and being completely surrounded by a depressed area. The dorsal marginal rim is produced downward a considerable distance anterior to the central pit. Surface otherwise smooth.

Length 0.63 mm.; height 0.34 mm.

Holotype from the Oligocene limestone at old Fort St. Stephens bluff on the Tombigbee River, Alabama. Louisiana State Univ., Mus. No. 596.

This species ranges to the top of the Vicksburg Oligocene, its anterior marginal rim becoming steadily lower and more rounded until in the Byram marl at Byram, Mississippi, it is no higher than the posterior rim.

CYTHERELLOIDEA VICKSBURGENSIS
Howe, n.sp.
Plate 5, figure 6

Carapace in side view oblong. Dorsal and ventral margins parallel. Anterior end evenly rounded. Posterior end obliquely rounded, sharpest at the ventral angle. A sharp marginal ridge starts at the anterior-dorsal angle, curves around the anterior border and follows the ventral edge to the posterior ventral angle. Two elongate narrow ribs extend from the raised posterior margin beneath the subcentral pit to the anterior quarter of the valve but stop well short of the an-

terior marginal rim. The uppermost of the two ribs is joined near its ends by two cross ribs which outline an elongate depression about the subcentral pit. The anterior of these two cross ribs follows the dorsal margin back to the posterior dorsal angle. Surface otherwise smooth.

Length 0.66 mm.; height 0.34 mm.

Holotype from the middle Vicksburg Oligocene 150 yards above the falls of Mint Spring Bayou, Vicksburg, Mississippi. Louisiana State Univ., Mus. No. 597.

This species is present with slight modification in the Byram marl at Byram, Mississippi.

CYTHERELLOIDEA LEONENSIS Howe, n.sp.
Plate 5, figure 9

Carapace in side view oblong. Dorsal margin straight except for an arched hump posterior to the middle. Ventral margin straight. Anterior end evenly rounded. Posterior end subtruncate. A raised rim follows around the anterior margin and extends backwards along the ventral margin to the posterior angle. It also extends backwards some distance below the dorsal margin almost to the posterior edge. Between these two continuations of the anterior rim are two ribs which arise from raised bumps on the posterior margin. The uppermost dies out before reaching the middle of the valve, but the lower rib continues until it connects with the anterior rim just above the anterior-ventral angle. A very faint pit is evident at almost the exact center of the valves. Surface otherwise smooth.

Length 0.62 mm.; height 0.32 mm.

Holotype from the Choctawhatchee Miocene on Harvey's Creek 2 miles up the creek from the Ocklocknee River, and 18 miles southwest of Tallahassee, Florida. Material collected by the Florida Geological Survey. Louisiana State Univ., Mus. No. 598.

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APERTURAL CHARACTERISTICS OF THE GENUS *HANTKENINA*, WITH DESCRIPTION OF A NEW SPECIES

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ABSTRACT

The genus *Hantkenina* was originally described as possessing a tripartite aperture and it is so described in recent textbooks. Several species have recently been assigned to the genus which do not possess tripartite apertures. The species here described as new possesses an elaborate apertural plate from which extend four tubular openings in addition to an elliptical opening at the base of the last chamber.

The genus *Hantkenina* was described by Cushman (1) in 1924, the species *H. alabamensis*, from the *Zeuglodon* bed of the Jackson Eocene at Cocoa post office, Alabama, being designated as genotype. Three other new species, *H. brevispina*, *H. longispina*, and *H. mexicana* were described at the same time and Hantken's (8) *Siderolina kochi* was redescribed as a *Hantkenina*. No data were given concerning the apertures of any of these last four species, the apertural characteristics of the genus being based on the type species, *H. alabamensis*, concerning which Cushman stated:

> . . . aperture tripartite one arm running along either side of the base of the chamber, the other extending peripherally in the apertural face of the chamber.

A text figure given by Cushman to illustrate the apertural features of this genus is reproduced here (Pl. 5, fig. 13).

These species were refigured and discussed in succeeding papers by Cushman (2, 3) but without further comment on the apertures. In 1927 Cushman (4) established the family Hantkeninidae, the features of which were given as follows:

> Test planospiral, at least in the young, involute, wall calcareous, perforate, each chamber with a long acicular spine; aperture a high arched opening often with basal lobes, or divided.

Howe (9, 10) in 1928 showed that *Hantkenina* extended into the Oligocene and described (9) an additional species, *H. inflata*, without noting further apertural characteristics, however. In 1928, also, Cushman (5) gave the range of the genus as "Upper Eocene and lowest Oligocene," but discussion of the aperture was taken from previous works. Cushman and Jarvis (6) in 1929 described *H. lerneri* and *H. alabamensis* var. *primitiva* from the Eocene of Trinidad and in the same year Wienzierl and Applin (14) described *H. dumblei* from the Yegua Eocene of Texas. None of these descriptions give added

information concerning the aperture of the genus.

Cushman and Wickenden (7) in 1930, however, made a radical departure from previous conception of the genus when they came to the conclusion that *Siderolina cenomana* Schacko (13) is an early Conomanian representative of *Hantkenina*.[1] This species and *H. multispinata* which they described from the Cretaceous of southern Manitoba are both characterized and figured as possessing an aperture which is a "low arch at the base of the last-formed chamber in the median line." They state further that the aperture of *H. multispinata* in the earlier stages lies in the median line, but in the adult extends outward to the umbilical area at least on one side, with a thin lip over the opening. One of their figures of this latter species is here reproduced (Pl. 5, fig. 16) to illustrate how different this aperture is from that previously attributed to the genus.

H. mexicana var. *aragonensis* was described in 1930 by Nuttall (12) from the Eocene of Mexico, but no mention was made of the aperture. Howe and Wallace (11) in 1932 described *H. mccordi* from the Jackson Eocene of Louisiana. The aperture of this species appears so different from that of others previously described that it also is refigured (Pl. 5, fig. 15). Concerning *H. mccordi* it is stated:

> Aperture an elliptical opening located at the contact of the last chamber with the preceding coil, provided with irregularly spaced, short teeth, the aperture so large that part of the preceding coil with the inclosed spine of the previous chamber can be seen through it; the aperture of the next to the last chamber also remains open at the umbilicus.

To the variety of apertures which have already been described and assigned to *Hantkenina*, the present authors add that of *H. danvillensis* whose description follows. The authors found only one specimen of this species and suspected that it might be unique, but subsequently Mr. M. C. Israelsky has found a similar specimen, concerning which he wrote as follows:[2]

> In the Danville samples you gave me I found one specimen of the *Hantkenina* with multiple apertures. I notice the shell seems very thin in the area of the apertures and I wonder if it is possible that the animal was resorbing the wall before moving through to start another chamber or perhaps for the purpose of facilitating cell division.

It appears then from the two specimens, that the apertural plate presented by this species is a definite characteristic belonging to the species, if not to all members of the genus. The senior author has examined several hundred specimens of *H. alabamensis*, *H. longispina* and *H. brevispina* looking for similar apertural features, but he was unable to find anything that remotely resembled this elaborate apertural plate. *H. alabamensis*, however, does have a well developed supplementary lip which can be observed in well-preserved specimens about the borders of its tripartite aperture.

[1] *Siderolina cenomana* Schacke was selected as the genotype of the new genus *Schackoina* Thalmann, *Eclogae geol. Helv.*, vol. 29, p. 289, 1932.

[2] Letter written October 6, 1932.

From the great variety of apertures which have been assigned to *Hantkenina* it seems that the only feature which the species have in common is the possession of hollow spines extending out from the chambers—a feature possessed by several other closely related genera. This genus may eventually be subdivided, but the present writers have little hesitation in classifying *H. danvillensis* as a *Hantkenina*, since it differs from the genotype, *H. alabamensis*, only in the character of the apertural plate and in the greater inflation of the chambers.

HANTKENINA DANVILLENSIS Howe and Wallace, n.sp.

Plate 5, figures 14, 17

Test planispiral, bilaterally symmetrical; periphery lobate; chambers inflated five in the last coil, each provided with a long hollow spine, located on the periphery near the contact with the next younger chamber; wall smooth, calcareous, finely perforate; aperture an elliptical opening at the base of the last chamber, above which is an elaborate supplementary apertural plate out of which extend four tubular openings which are round or elliptical in shape. Diameter without spines, 0.55 mm.

From the Jackson Eocene, at Danville Landing on the Ouachita River, Catahoula Parish, Louisiana.

This species differs from *H. alabamensis* in the character of its aperture and in possessing more inflated chambers. It differs from *H. mccordi* in possessing much more elongated spines.

Holotype, Louisiana State Univ., Mus. No. 599.

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DECAPOD CRUSTACEANS FROM THE MIDDLE EOCENE OF TEXAS

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ABSTRACT

The paper describes crustacean fossils and discusses the localities in the lower Claiborne (middle Eocene) of Texas at which they were found. The genera *Harpactocarcinus* and *Calappilia* are found in the Crockett member and the genus *Zanthopsis* is found in the Weches member. The genus *Callianassa* is found in both members.

INTRODUCTION

The work reported here is part of a study of the lower Claiborne fauna of Texas. This study has been carried on for the last five years. During this time many fossils were collected chiefly in the vicinity of the Agricultural and Mechanical College of Texas. The crustaceans are the first group prepared for publication.

The Claiborne group, according to T. W. Vaughan (13, p. 694),[2] is equivalent to the European Lutetian and Auversian. In Texas, the Claiborne group is represented by the Mount Selman, Cook Mountain, and Yegua formations, of which the first two compose the lower Claiborne. The lower Claiborne of East Texas, that is, the Mount Selman and Cook Mountain formations, have recently been subdivided in several members by Wendlandt and Knebel (14). Named in ascending order the members are: Carrizo, Reklaw, Queen City, and Weches in the Mount Selman formation; Sparta and Crockett in the Cook Mountain formation. The upper part of the Claiborne group is represented in Texas by the Yegua formation of which, however, the lowermost beds as exposed from Brazos to Lee counties represent lower Claiborne time according to Gardner (3) and Renick and Stenzel (12, p. 98).

Of these members the Crockett is the richest in fossil crustaceans. In it were found *Harpactocarcinus americanus*, *H. rathbunae*, *H.* sp., *Calappilia diglypta*, and *Callianassa brazoensis*. The Weches member has so far furnished only three species and one variety, *Zanthopsis peytoni*, *Zanthopsis peytoni* var. *parva*, *Callianassa wechesensis*, and an as yet undescribed species of *Zanthopsis* discovered after completion of this report. The other, largely nonmarine members, very probably do not contain any fossil crustaceans in this region.

[1] This paper gives the results of research done under a Grant-in-Aid from the National Research Council, Washington, D. C. Further publications are to follow.

[2] Numbers in parentheses refer to the index of literature on p. 56.

DESCRIPTION OF LOCALITIES

Most of the material was collected along Little Brazos River, both above and below the bridge of the present Bryan-Steele's Store county road. This location is 9.6 miles west of Bryan, Brazos County, Texas, and is the site also of the former bridge of the now defunct Bryan & Central Texas Interurban Railroad. The new highway bridge of State Highway 21 (Bryan-Caldwell road) is being built a short distance below this locality.

The combined section above and below the bridge is as follows in descending order:

River terrace deposit (Pleistocene to Recent):

i. Red-brown loam with basal conglomeratic layer and many river mussel shells, occasionally a calcareous conglomeratic sandstone at the base. Bed 1 and 2 of William Kennedy (5, p. 126).

UNCONFORMITY

Crockett member of Cook Mountain formation:

	Thickness
h. Dark-brown shale, fossils decrease steadily toward the top.	12 ft.
g. Brownish-green, friable glauconite marl, highly fossiliferous	3 ft.
f. Occasional concretions of dense limestone, size 4 by 10 inches.	
e. Brownish-green, friable glauconite marl, highly fossiliferous	5 ft., 3 in.
d. Grey to yellow, impure limestone with short cone-in-cone structures, very irregular in thickness and often wanting, few fossils	0–11 in.
c. Brown to green glauconite marl; fossiliferous	2 ft., 4 in.
b. Red-brown, nodular, limonitic, fossiliferous limestone making a prominent, hard bench; *Anomia lisbonensis* Aldrich a common fossil. The Little Brazos limestone of the Crockett member of Renick and Stenzel (12, p. 92); bed 6 of Kennedy's section (5, p. 127)	4 in.
a. Green, fine, sandy, fossiliferous glauconite marl; *Plicatula filamentosa* a common fossil. Bed 7 of Kennedy (5, p. 127)	1 ft., 6 in.

The beds of the Crockett member have a slight apparent dip downstream so that below the bridge higher beds descend to the level of the river. Beds *a* to *g* are exposed above the bridge, *g* and *h* below the bridge. Most of the crabs were found below the bridge. The crustaceans found here were *Harpactocarcinus americanus*, *H. rathbunae*, and *Callianassa brazoensis*. They were found in the basal part of bed *h* and in beds *g*, *e*, *d*, and *c*.

The larger species, *Harpactocarcinus rathbunae*, is very rare. Dr. Rathbun (10) had only one individual (paratype *c* of Rathbun) and some fragments (paratypes *d* and *e* of Rathbun). The present writer found one more specimen. Both specimens were found free, not in concretions. The second individual was partly covered with lime matrix, perhaps an abortive concretion.

The smaller species, *Harpactocarcinus americanus*, is common at this place. Altogether nearly 100 individuals and fragments of individuals of this species from the Little Brazos River locality are at the writer's disposal now. It is found free, in limonitic limestone concretions, and most commonly in peculiar black concretions. The black concretions are much broken by shrinkage cracks in a polygonal pattern. The crabs, however, show some matrix-filled expansion breaks, which are older than the shrinkage cracks. These concretions were suggested to Mr. F. A. Burt for investigation and he reported on them elsewhere (1). The material of the concretions is hard and exceedingly brittle. It is impossible to remove the crabs from the center of the concretions without breaking them into countless fragments, which have to be fitted together again. Some specimens are composed of about 50 fragments. Therefore, it was not feasible to prepare all concretions on hand. The limonitic limestone concretions are less common. They are also much harder, more coherent, and have fewer shrink-

age cracks. Due to their hardness, it is difficult to prepare satisfactory specimens. A notable exception was the concretion containing specimen No. 11 which had a larger number of shrinkage cracks. The crabs found free are rare and of excellent preservation, if they have not been exposed for too long a time.

Callianassa brazoensis is found free and is associated with the same kinds of concretions. However, it does not form the center of the concretions as *Harpactocarcinus americanus*. Only sixteen claws of this *Callianassa* are available.

The crabs at this locality were discovered in 1926 by Mr. John E. Adams and the writer. The larger species of *Harpactocarcinus* was found first by Mr. Adams and the smaller was found first by the writer. *Callianassa brazoensis* was found only recently. Mr. Adams sent his material to Dr. Mary J. Rathbun, who described *Harpactocarcinus americanus* from it (10). This material was less plentiful and in poorer preservation than the material which has accumulated in the writer's collection during the last five years. The present paper includes further descriptions and a revision of the species *Harpactocarcinus americanus* as described by Rathbun.

A lower horizon of the Crockett member of the Cook Mountain formation is exposed in the bed of a branch of Campbell's creek, which directly adjoins the old San Antonio-Nacogdoches trail, 2.85 miles northeast of its junction with State Highway 6 (Bryan-Hearne road), Brazos County, Texas. The section at this place is as follows:

Thickness

Subsoil and terrace material (Pleistocene to Recent:

d. Yellowish-brown, not bedded marl, containing some poorly sorted gravel, especially at the base..... 7 ft.

Crockett member of Cook Mountain formation:

c. Fresh, light-buff to weathered, rusty-yellow shale with 2 inch thick stringers of crowded, friable, weathered fossils..... 4 ft.

b. Green glauconite marl, highly fossiliferous, containing the crabs..... 1–2 ft.

a. Irregular, red-brown, limonitic, fossiliferous limestone making a prominent hard bench at the bottom of the creek. The Moseley limestone of Renick and Stenzel (12, p. 91–92)..... 6 in.

Here were found one large cheliped of an indeterminable species of *Harpactocarcinus* (*H.* sp.) and two specimens of *H. americanus*. So far as is known, fossil crabs were found here first by Dr. Lyman C. Reed, then of the Rio Bravo Oil Company.

Nearby is a third locality, in the north ditch of the old San Antonio-Nacogdoches trail, 2.7 miles northeast of its junction with State Highway 6, and in the Byer 65 acre tract, near the southeast corner of Skeagh Walker survey, Robertson County, Texas. This locality is about 25 feet stratigraphically higher than the last one. The small black concretions found here in light-buff to yellow gypsiferous shale are very similar to those of the Little Brazos River and are at the same stratigraphic level. Two of these concretions contained each a poorly preserved crab, *Harpactocarcinus americanus*.

The fourth locality is about 70 miles farther east; it is the bluff on Hurricane or Threemile bayou, 0.3 mile above the bridge over this creek, 3.35 miles north-northeast of the Houston County court house on the Crockett-Rusk road (mail route No. 1), and in the southeast corner of Young-Murchison 553½ acre tract and H. F. Craddock 277.4 acre tract, in the southeast corner of Newell C. Hodge survey, Houston County, Texas. This locality is known in older literature as the old Jones farm. Three free specimens of *Harpactocarcinus americanus* were found here.

The four localities described above belong to the Crockett member, are stratigraphically near each other, and contain the same crabs, mostly *Harpactocarcinus americanus*. The larger species, *Harpacto-*

carcinus rathbunae, was found only at one locality, along the Little Brazos River, and is too rare to be used as a check in stratigraphy.

The fifth locality is stratigraphically lower in the Crockett member. It is on the right bank of the Brazos River, above and below the Houston & Texas Central Railroad bridge and above the new bridge of State Highway 21 (Bryan-Caldwell road) in Burleson County; it is known also as Moseley's Ferry or Stone City. Fossils are abundant at this locality, but only two specimens of the rare *Calappilia diglypta* were found. Loose dactyli of this *Calappilia* are found in washed residues of the main glauconite.

The section above the bridge as measured by the writer is as follows:

	Thickness
River terrace deposit (Pleistocene to Recent):	
j. Red-brown loam with basal conglomeratic layer. Bed 1 of Kennedy (5, p. 128).....	15 ft.
UNCONFORMITY	
Crockett member of Cook Mountain formation:	
i. Brown, weathered, fossiliferous glauconite marl forming concentric concretions. Bed 2 of Kennedy.....	5 in.
h. Brown, weathered, fossiliferous glauconite marl; the basal part contains some heavy adult *Ostrea sellaeformis* Conrad. Bed 3 of Kennedy.....	3 ft., 3 in.
g. Hard, brown, weathered, impure, fossiliferous limestone forming a prominent bench. The Moseley limestone of Renick and Stenzel, (12, p. 91) and bed 4 of Kennedy (5, p. 128)...	2 ft.
f. Partly brown weathered, and partly fresh green glauconite sand with many fossils.....	1 ft., 2 in.
e. Dark shale, fossils rare.....	4 ft.
d. Fresh, green, fossiliferous glauconite sand.....	1 ft., 7 in.
c. Dark, non-fossiliferous shale ..	1 ft., 10 in.
b. Dark-green, fresh, massive, marly glauconite sand containing irregular, brown, limonitic limestone concretions and forming a lower, prominent bench. This is the main glauconite of the section. The two crabs were found in the middle of the bed. The top of the bed contains limonitic concretions, is covered with many rolled shells, and is especially rich in otoliths, teeth, and other resistant fossils. The glauconite sand corresponds to Kennedy's bed 9, the top corresponds to bed 6..	5 ft., 1 in.
a. Dark shale with some fossiliferous glauconite stringers, generally free of fossils, extends down to water level. Bed 10 of Kennedy (5, p. 129).	

All other localities are in the Weches member in Leon County. The localities and the fossil crustaceans are as follows:

1. Cuesta scarp at left bank of Navasota River, at old abandoned iron bridge over the Navasota River in E. C. Watson 800 acre tract, Jose Maria Viesca survey, southwestern Leon County. Three specimens of *Zanthopsis peytoni*.

2. In north ditch of Marquez-Flynn mail route, 5.75 miles east of Marquez, on outlier of Weches member in Mrs. Louisa Gamble 176 acre tract, Joshua Townsend survey, Leon County. One specimen of *Zanthopsis peytoni* and four specimens of *Callianassa wechesensis*.

3. Knoll of Weches scarp, northeast of private road in northeast corner of L. V. Neyland 240 acre tract, Wm. Mann survey (42), Leon County. Two specimens of *Zanthopsis peytoni* var. *parva*.

4. In north ditch of Trinity and Brazos Valley Railroad about 0.15 miles west of railroad underpass, 1 mile southwest of Robbins and approximately in middle of northeast line of W. H. Speer 129 acre tract, J. Johnston survey, Leon County. One specimen of *Zanthopsis peytoni* var. *parva*.

5. In north ditch of Concord-Robbins road, 0.1 mile east of brick high school of Concord, in southeast corner of Concord townsite, George E. Dwight survey, Leon County. One specimen of *Zanthopsis peytoni* var. *parva*.

6. In north ditch of Robbins-Centerville highway, 0.6 miles southeast of Robbins depot, in south corner of J. M. Powell 100 acre tract, south corner of R. M. Tyus survey, Leon County. One specimen of *Zanthopsis peytoni* var. *parva*.

7. Bald Mound, 4 miles northwest of Centerville, in H. R. Benson 70 acre tract, Robt. Woods survey, Leon County. 29 specimens of *Zanthopsis peytoni*.

After completion of this report several additional localities and spec-

imens have been found in the Weches in Leon County.

The section exposed at the localities is generally similar. For this reason and because the writer intends to publish a detailed account of the geology of Leon County later on, only a generalized section will be given here:

Weches member of Mount Selman formation:

g. Red, weathered, glauconitic, fossiliferous marls..... 10–20 ft.
f. Grey to brown limestone forming large rounded concretions, discontinuous. Corresponds to lentil B of Renick and Stenzel (12, p. 79) in counties further west..... 1 ft.
e. Layer of *Ostrea sellaeformis* Conrad and *Venericardia planicosta* Lamarck..... 1 ft.
d. Grey to brown, powdery marls with white calcareous nodules, frequently covered with slumped materials..... 5 ft.
c. Grey, roughly pitted limestone forming prominent benches. Corresponds to lentil A of Renick and Stenzel (12, p. 79) in counties further west..... 1–2 ft.
b. Red-brown, weathered, glauconitic sands and marls with *Ostrea sellaeformis* Conrad.... 1 ft.

Queen City member of Mount Selman formation:

a. Grey-brown, silty, lignitic shales.

Beds *b* to *d* form the basal part of the Weches member, which makes a steep scarp in this region. *Zanthopsis peytoni* in its typical form is restricted to bed *d* and occurs in rough nodular lime concretions, the variety *parva* is restricted to bed *g* and occurs free. Both forms are common enough to be used as guide fossils for their respective levels.

STATUS OF *HARPACTOCARCINUS AMERICANUS* RATHBUN

The study of crabs is somewhat complicated by their sexual dimorphism. Male and female of a species often differ so much that they can easily be mistaken for two different though related species. Male crabs generally have a narrow triangular or spear-shaped abdomen, larger chelipeds, and a broader carapace. Females have a broad triangular abdomen when immature, and an almost semicircular abdomen when mature. Their chelipeds are smaller, the carapace longer in comparison with the male. [Compare E. P. Churchill, Jr. (2, p. 103–104) and Zittel-Eastman (16, p. 767, figs. 1492, 1493)]. In studying a new species these sex characteristics are important. Chelipeds and carapace shape are not very reliable characteristics, as they are relative. The shape of the abdomen is not relative and is, therefore, of prime importance. If the abdomen is preserved, mistakes as to the sex cannot be made.

In this connection it has been very interesting to note the species *Harpactocarcinus americanus* as described by Dr. Mary J. Rathbun (10). From the material then available were described three small females and a very different large male. In the much larger material now available, however, there are many other smaller males which differ very much from the large male described by Dr. Rathbun, but do not differ very much from the females. In fact, these newly discovered males are so similar to the females that in cases where the abdomen is not preserved a distinction as to the sex can be made only with great difficulty or in some specimens not at all. In the following table some of the distinctive characteristics of the different males and females are assembled for compari-

Sex and specific characters of Harpactocarcinus *from Little Brazos River*

Character	*Females*	*Small males*	*Large males*
Size of carapace (width by length)	38–53 by 31–44 mm.; average size 45 by 36 mm.	37–57 by 28–43 mm.; average size 47 by 36 mm.	63 by 50 mm.
Ratio, width of carapace to length of right palm	2.81:1 to 2.64:1	2.59:1 to 2.23:1	1.91:1
Arching of carapace from front to back	Highly arched	Highly arched	Slightly arched
Tubercles on outside surface of right palm	Conspicuous, sharply elevated	Sharply elevated	Inconspicuous, flattened
Lower margin of right chela	Straight, end convex	Almost straight, end convex	Concave, end more convex
Proximal tubercles on inner margin of upper surface of right palm	5, about equal in size and spacing	5, about equal in size and spacing	4, unequal in size and spacing
Teeth on occludent margin of fixed finger on right hand	Near middle of finger	Near middle of finger	Near base of finger

(See also Plate 6, figs. 1 and 2).

son. Only specimens which include the abdomen, and could thus be determined as to their sex are used for this tabulation.

From this and the species descriptions below, one may infer that the females and the smaller, newly discovered males belong to one species, here called *Harpactocarcinus americanus*. The large male previously described by Dr. Rathbun (10) as belonging to the same species is a representative of another species here called *Harpactocarcinus rathbunae*. So far females corresponding to the larger males have not been found.

DESCRIPTION OF SPECIES

Family XANTHIDAE

Genus HARPACTOCARCINUS A. Milne-Edwards

Harpactocarcinus A. MILNE-EDWARDS, *1862*, Histoire des Crustacés Podophthalmaires Fossiles, tome 1, Annales Sci. Nat., (4), Zool. vol. 18, pp. 46 and 64; type, *H. punctulatus* (Desmarest) from the Eocene of Priabona, Italy.

HARPACTOCARCINUS AMERICANUS M. J. Rathbun emend. nobis

Plate 6, figures 1*a–e*

Harpactocarcinus americanus RATHBUN (partim), *1928*, U. S. Nat. Mus., Proc., vol. 73, article 6; females, holotype and paratypes *a* and *b;* not paratypes *c*, *d*, and *f*.

Xanthopsis americana (RATHBUN) in M. F. Glaessner, *1929*, Fossilium Catalogus, I: Animalia, pars 41, p. 395.

?H. americanus MARY J. RATHBUN, *1930*, U. S. Nat. Mus., Proc., vol. 78, art. 8, p. 1.

H. americanus RATHBUN emend. STENZEL in B. C. Renick and H. B. Stenzel, *1931*, Texas Univ., Bull. 3101, pp. 94, 99 and pl. 7, fig. 18.

The following supplements the original description of females:

The chelae are unequal in size, the right one being about one and one-half as large as the left. The upper surface

of the right palm is bordered by rows of tubercles on both margins. The outside row carries one large, longitudinally elongate tubercle on its distal end, a row of three to five conical granules in the middle, and a rounded lobe overlapping the proximal joint. The row on the inside margin of the upper surface consists of larger tubercles than the corresponding ones on the outside margin. There are a large, longitudinally elongate, distal tubercle and five smaller conical ones extending from about the middle to the proximal end. This proximal end of the inside margin is crest-shaped and recurved to the inside. The inner surface has through the middle a short, longitudinal line of three to four granules. The carpus of the right cheliped is conical and bluntly rounded, its outside surface subtriangular, ending proximally in a blunt point. There is another blunt point on the upper distal end. The merus of the right cheliped is short, stout, a little longer than wide, its edges bluntly rounded. The left palm, although much smaller, is essentially similar except that the proximal end of the inside margin of the upper surface is narrower and more recurved than in the right palm. The fingers of the left chela are as yet incompletely known.

Description of males.—The carapace is almost one-third wider than long, in all other features the same as in the females. The well-preserved front between the eyes shows a subtriangular, blunt tooth adjoining each orbit, and two more, median teeth which are more advanced, horizontally flattened, and round. The under side of the carapace shows fine and close granulation on the margins and on the pterygostomian ridge. The recesses of the antennules are deep and obliquely placed. The sternum is similar to that of the female, but the oblique teeth on the sternum at the base of the chelipeds are lower and less conspicuous. The longitudinal median groove of the sternum is shallower as far as it is not covered by the end of the abdomen. There is a deep groove on the anterior or first segment of the sternum extending in a broad V-fashion from in front of the abdominal tip to the anterior margin of the sternum in front of the base of the chelipeds. This groove is also present in the females, but is largely covered by the broad abdomen. The abdomen is narrow and somewhat shorter than in the female, the tip not extending beyond the region of the oblique sternal tubercles. The seventh (last) segment is triangular, somewhat narrower than long, with slightly sinuous margins. The suture between the seventh and sixth segment is gently sinuous. The sixth segment is almost square, a little wider than long. The lateral margins are fairly straight. The suture between the sixth and fifth segment is straight. The fifth, fourth, and third segments are fused into one piece. It has a broad, median groove separating a pair of large tubercles at the proximal end. Its outline is trapezoidal with flares at the base which make it about one-half wider at the base than at the distal end. The second segment is short and slightly narrower than the base of the third segment. The first segment which is rarely visible seems to be short and as wide as the second segment.

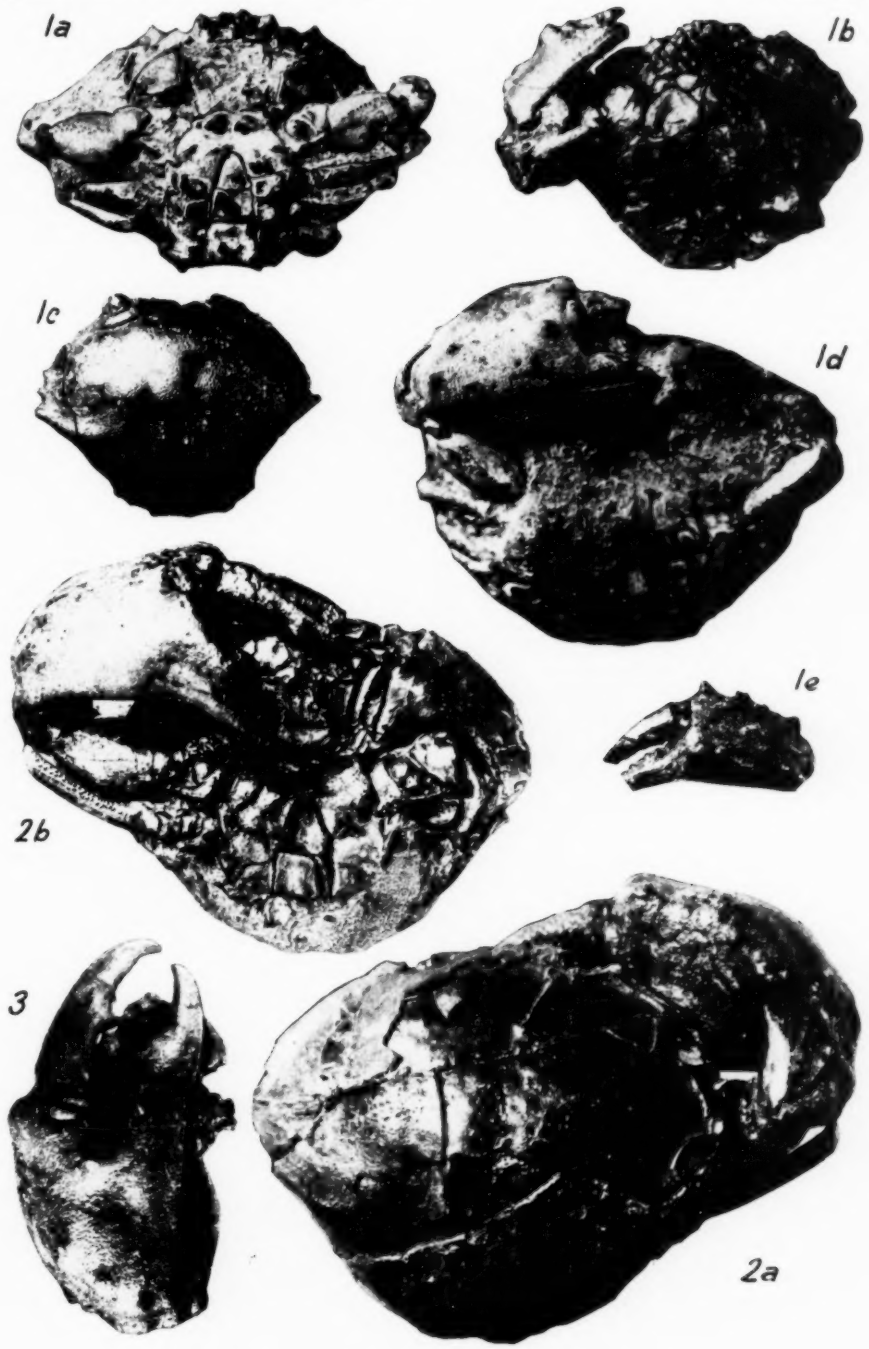
The chelipeds are incomplete in the

EXPLANATION OF PLATE 6

FIGS. 1*a–e*—*Harpactocarinus americanus* Rathbun emend. Stenzel. *a*, male, type 1, ventral view, 0.92 of natural size; *b*, female, type 7, ventral view, 0.91 of natural size; *c*, female, type 5, dorsal view, 0.92 of natural size; *d*, female, type 25, ventral view, 1.09 of natural size; *e*, male, type 72, outer surface of left manus, 0.98 of natural size.

2*a–b*—*Harpactocarcinus rathbunae* Stenzel, male, holotype. *a*, dorsal view, 1.04 of natural size; *b*, ventral view of same, 0.92 of natural size.

3—*Harpactocarcinus* sp. Stenzel, male, holotype, right manus, 1.03 of natural size.



Stenzel, Eocene decapod crustaceans

specimen figured (Pl. 6, fig. 1*a*). The left coxa, the one which is preserved, is narrow, L-shaped, bearing a low tubercle on the inner corner. The ischium of both chelipeds carries a sharp anterior edge which is extended to form a lamina. The merus of both chelipeds is short, stout, and triangular in cross-section. The anterior edge is bluntly rounded, the ventral edge is granulate, and the posterior edge is bluntly rounded. The anterior surface is almost flat. At the distal end of the ventral edge and separated from it by a depression is a lobe which is turned over to the anterior side and overlaps the merus-carpus joint. The carpus is preserved on both chelipeds and is very similar to that of the female. However, the surface granulation is coarser in the male, the distal points are more conspicuous.

The three first ambulatory legs are partly preserved. The cross-section of the merus, carpus, and propodus is elliptical. The bluntly rounded anterior edge of the merus, carpus, and propodus is finely granulate. The length of the first ambulatory merus is 16 mm., of the carpus which is almost entire, 8 mm., of the propodus 8 mm. as far as it is preserved. (Description from specimen 1.)

The right chelae are larger, more massive, and more inflated in the male than in the female. The ornamentation is essentially the same although the tubercles are somewhat less conspicuous. The distal tubercle on the outside of the manus is more remote from the interdigital sinus than in the female. (Description from specimen 11.)

Several specimens (4, 11, 26, 28, 33, and 72) have the left chelae preserved. Their ornamentation is essentially the same as of the right chelae. However the tubercles of the manus are very high and conspicuous. The fixed finger is bent down at an angle of 155 degrees from the manus. Both fingers are slender, their occludent margins set with a row of small, even-sized tubercles or teeth.

Dimensions.—Specimen 1, male, width of carapace measured to the bases of the lateral spines 46 mm., length of carapace 36 mm. Specimen 11, male, width of carapace measured as above 52 mm., length of carapace 43 mm., length of right palm up to interdigital sinus 21 mm. Specimen 7, female, width of carapace 45 mm., length of carapace 36 mm., length of right palm 16 mm. Specimen 5, female, width of carapace 40 mm., length of carapace 32 mm.

Type specimens.—Holotype of this species is Rathbun's holotype of *H. americanus* in the U. S. Nat. Mus., Cat. No. 369,607. Rathbun's paratypes *a* and *b* are also in the U. S. Nat. Mus.

There are about 100 topotypes and seven more specimens from the other three localities in the author's collection at College Station, Texas.

Localities.—Little Brazos River, Brazos County, (type locality); Creek bed directly adjoining the old San Antonio-Nacogdoches trail, 2.85 miles northeast of State Highway 6 (Bryan-Hearne road), Brazos County; Ditch alongside the old San Antonio-Nacogdoches trail, 2.7 miles northeast of State Highway 6 (Bryan-Hearne road), Robertson County; Hurricane Bayou, Houston County, Texas. Possibly also: Zardo Creek eastern Mexico, comp. Rathbun (11).

Geologic horizon.—Middle Eocene, Claiborne group, Cook Mountain formation, Crockett member.

Diagnosis.—This species resembles *H. rathbunae*. However, it is smaller, the right chela compared with the carapace is much smaller, the lower margin of the right manus is straight, the outside surface of the right palm has more conspicuous tubercles, and there are five equal and evenly-spaced proximal tubercles on the inner margin of the upper surface of the right palm. The fixed finger on the right hand is shorter, stouter, and has its teeth near the middle of the occludent margin.

HARPACTOCARCINUS RATHBUNAE
Stenzel, n.sp.

Plate 6, figures 2*a*, *b*

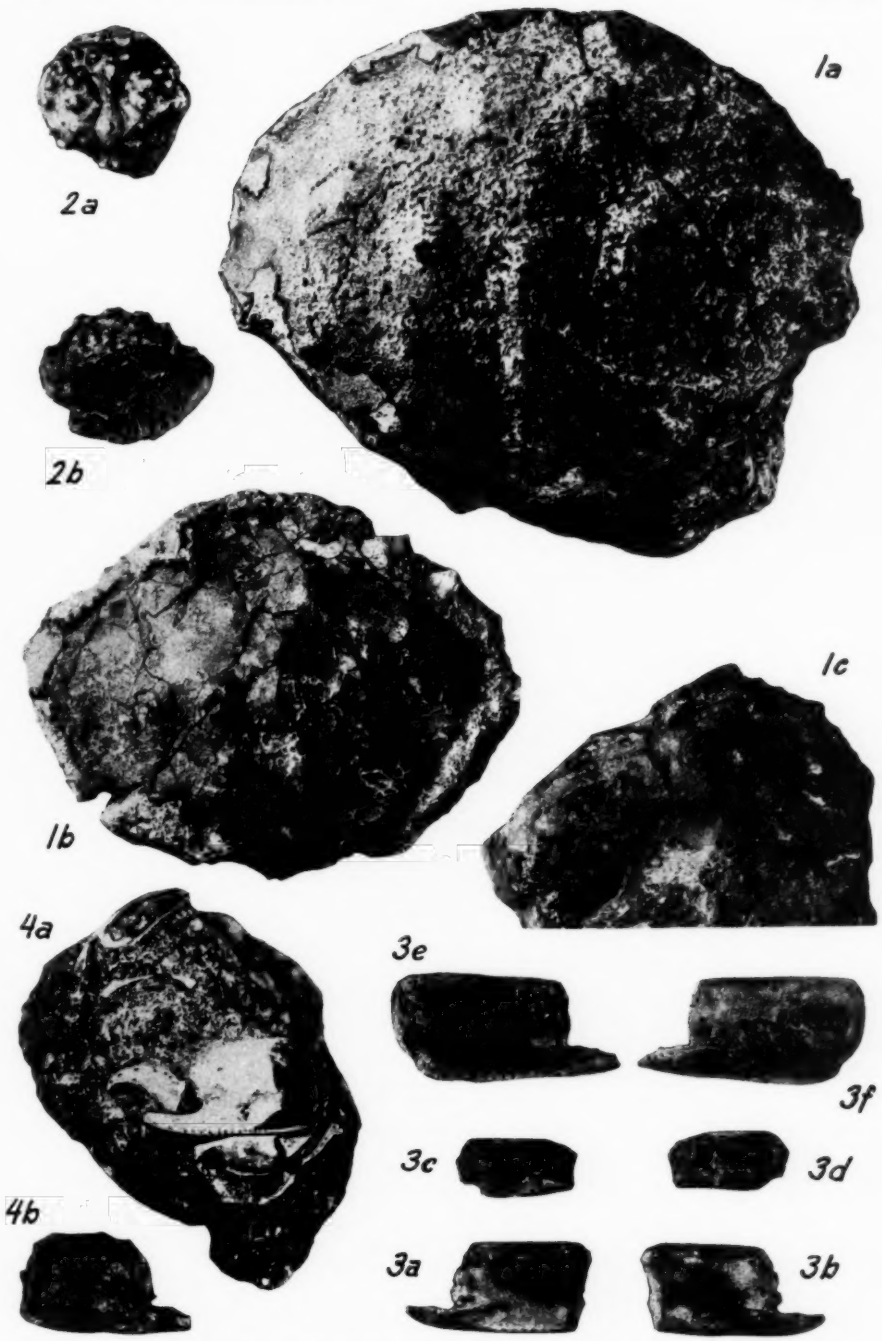
Harpactocarcinus americanus RATHBUN (partim), *1928*, U. S. Nat. Mus., Proc., vol. 73, article 6; male paratypes *c*, *d*, and *f* only; not holotype and paratypes *a* and *b*.
H. rathbunae STENZEL in B. C. Renick and H. B. Stenzel, *1931*, Texas Univ., Bull., 3101, 94, 99.

So far only the males of this species are known. They are large. The width of the carapace is 63 mm., its length in the type specimen, 50 mm. Both measurements are only approximate within about 2 mm. as the carapace is somewhat broken on the edges. The carapace is preserved as an internal mold with a few fragments of the armor in place. These are closely punctate and sparingly granulate. As a whole the carapace is flattish, a little more convex from front to back than from side to side. From either side of the widest part of the mesogastric region a broad, nearly longitudinal furrow runs back to the intestinal region, stopping short of the posterior margin. A large and low swelling occupies the inner angle of the branchial region. A larger, less well-defined swelling adjoins it in antero-lateral direction. From the lateral tooth, which is broken off, a very blunt ridge runs backward and inward and upward on to the dorsal surface. At the end this ridge flattens out and merges into a flat surface near the postero-lateral margin. The postero-lateral margin is very thick, gently rounded, and poorly defined. There are five well defined and small swellings on the mold: an unpaired one on the median line about one-fifth of the length of the carapace removed from the posterior margin, a pair of slightly elongate ones on the median, cardiac ridge about one-third removed from the posterior margin, and a pair of somewhat wider ones on the lateral sides of the protogastric region about one-fourth of the carapace length removed from the inner angle of the orbits. These swellings are not distinctive species characteristics as they have been found also on molds of *H. americanus*. They do not show on the outside surface of the armor in the latter species. The antero-lateral margin is thin, blunt, and coarsely granulate as far as the armor is preserved. There are four teeth or their broken bases visible, a fifth one might have been present, but is not preserved. The lateral tooth, to judge from its broken base, must have been the largest. The base of the next one (the fourth?) is as large as the one of its anterior neighbor. The latter (the third?) is well preserved as is its anterior neighbor (the second?). The third (?) is about 1.5 mm. high and points with the sub-branchial surface upward and outward. Similar but smaller is the second (?) tooth. The region of the first tooth—if there ever was one—is broken off. The distances between the teeth are as follows: orbit to second (?) 15 mm., second (?) to third (?) 8 mm., third (?) to fourth (?) 5.5 mm., and fourth (?) to lateral 4 mm.

The orbits are poorly preserved and

EXPLANATION OF PLATE 7

FIGS. 1*a–c*—*Zanthopsis peytoni* Stenzel. *a*, holotype, dorsal view, 1.02 of natural size; *b*, paratype, 3, dorsal view, 0.91 of natural size; *c*, paratype 7, right manus, 1.14 of natural size.
2*a–b*—*Calappilia diglypta* Stenzel, holotype. *a*, dorsal view, 0.91 of natural size; *b*, view of left side, 1.03 natural size.
3*a–f*—*Callianassa brazoensis* Stenzel, 1.79 of natural size. *a*, female?, holotype, inner surface of right manus; *b*, same, outer surface of right manus; *c*, same, inner surface of left manus; *d*, same, outer surface of left manus; *e*, male? paratype 2, inner surface of left manus; *f*, same, outer surface of left manus.
4*a–b*—*Callianassa wechesensis* Stenzel. *a*, in center: inner surface of right manus of holotype, at top: cross section of paratype 2, 2.00 of natural size; *b*, paratype 3, inner surface of left manus, 1.81 of natural size.



Stenzel, Eocene decapod crustaceans

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have, viewed from above, an upper margin of approximately semicircular outline. The outer angle is well advanced and narrow. At the lower inner angle there is a strong, conical, subacute tooth, more advanced than the outer tooth. The front between the orbits is missing.

The under side of the carapace is as a whole better preserved only the rear and fronto-lateral parts being amiss. The antennular recesses are obliquely placed and separated by a thick and bluntly toothed septum. The buccal cavity widens forward, its anterior margin is sinuous. The exognath and endognath of the maxillipeds are wide, the exognath widest at the middle. The endognath is obliquely placed, its ischium widening distally, and its merus is obliquely placed. Its anterior margin seems to fit against the arch of the buccal region.

The sternum carries a low, broad, oblique tubercle at the base of each cheliped. Only the last two segments of the male, narrow abdomen are preserved. The terminal segment is long triangular, its end shortened and subacute. It is 7 mm. long and about 6 mm. wide. The penultimate segment is nearly square with the base slightly wider than the distal end, and fairly straight sides.

Of the left cheliped there is but the coxa and ischium present. The right cheliped is complete with the exception of the dactylus tip and the outside of the carpus, which is partly eroded. The coxae are short and wide; the posterior flange is especially narrow. The ischia are short, stout, and triangular in cross-section. Their edges are bluntly rounded. The anterior edge, however, is produced to form a sharp, thin lamina. The right merus is short, stout, and more inflated than in *H. americanus* male. The cross-section is inflated triangular. The ventral edge carries a row of loosely spaced granules of which there are only eleven. The distal end of the ventral edge is broken off; it might have carried a lobe. The anterior surface of the merus is gently curved. The carpus is short, stout, inflated, and conical. Granules are rare on its surface. There is a short spine on its upper distal end. The manus is large, inflated, increasing rapidly in height in distal direction. The lower margin is very sinuous due to the reflexed position of the fixed finger. The outer surface bears a broad, but low tubercle opposite the interdigital sinus, and also three proximal tubercles in an oblique line. The uppermost of the proximal tubercles is a low, short, longitudinal ridge, highest at its middle and sloping down to both sides. The central one of the three tubercles is wide, round, and low; the last tubercle is conical and is the most prominent. The upper surface of the palm is narrow, oblique, and convex in both directions except at the distal end. It is bounded from the outer surface by a low indistinct ridge and from the inner surface by a more distinct ridge. The outer margin of the upper surface carries a low longitudinal tubercle on the distal end, very indistinct indications of three or four tubercles at its middle, and perhaps a lobe overlapping the carpus joint. However, this part is broken off. The inner margin carries a higher longitudinal tubercle at the distal end, which makes a depression together with the tubercle of the outer margin, and a row of four tubercles on the proximal two-thirds of the margin. The largest tubercle is the first proximal one. It carries two heads and points inward. The others are lower consecutively so that the last one is barely noticeable. The inner surface has a short longitudinal line of granules near its proximal third. The fixed finger is very broad at the base but tapers rapidly to a long narrow hooked finger of oval cross-section and subacute tip. There are near the base of its occulent margin, two large conical and coalescing teeth of which the proximal one is the larger. Parallel to the lower margin of the fixed finger runs a shallow groove which disappears toward the palm and beyond the middle of the finger. The dactylus, as far as it is preserved, is

fairly straight and has almost parallel outer and occludent margins. It is thick at the base but tapers rapidly to an oval cross-section. There is a large conical tooth near its base and a slightly smaller one at about the middle. These two teeth fit to both sides of the propodal tooth. A third very small tooth adjoins the second one distally. The tip of the dactylus is missing. The coxa, ischium, and merus of the first right ambulatory leg are preserved. The cross-section of the merus is oval. Rows of granules occupy both margins.

Dimensions.—Width of carapace to the bases of the lateral spines 63 mm., length of carapace 50 mm., length of right palm up to the interdigital sinus 32 mm., height of the right palm at its distal end 28 mm., length of the fixed finger of the right chela 25 mm.

Type specimen.—Holotype in the writer's collection at College Station, Texas. The specimen and fragment described by Rathbun are topotypes, they are in the U. S. Nat. Mus.

Locality.—Little Brazos River, Brazos County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Cook Mountain formation, Crockett member, about 4 feet above the nodular limestone ledge, the Little Brazos limestone of Renick and Stenzel (12).

Diagnosis.—This species is similar to *H. americanus*. It is, however, much larger. The right manus is larger and more inflated. The lower margin of the right manus is very sinuous.

This species is named in honor of Miss Mary J. Rathbun of the U. S. Nat. Mus.

HARPACTOCARCINUS sp.

Plate 6, figure 3

H. sp. STENZEL in B. C. Renick and H. B. Stenzel, *1931*, Texas Univ., Bull. 3101, pp. 94, 99.

This specimen—a large right cheliped—cannot be safely placed among the two species described above. It seems to stand near to *H. rathbunae*, yet it differs distinctly from the cheliped of the male. There is just enough of the abdominal tip preserved to show that it belongs to a male.

The manus is little inflated and increases very little in height in distal direction. Its surface including the tubercles is densely and finely granulated. The general arrangement of the tubercles is the same as in *H. rathbunae*, however, their shapes differ markedly. The interdigital tubercle is high and bluntly pointed and its slopes to the upper distal end of the manus are almost vertical. The two lower of the three proximal tubercles on the outer surface are high conical with the tips broken off. The third one is a ridge of 4.5 mm. length and nearly constant height, the distal end perhaps being a trifle higher than the rest of the ridge. The two distal longitudinal tubercles of the upper surface are prominent and the inner one is the larger. The other tubercles of the outer margin on the upper surface are missing. The inner margin carries five fairly evenly spaced and equal tubercles which are high and rounded. They occupy a little more than one-half of the inner margin. The fixed finger is broad and wide at the base and tapers rapidly at the middle. The distal half is slender, of high oval cross-section, and ends in a subacute point, turned forward and upward. There are two large, broad, and coalescing basal teeth at the occludent margin. A third small, round tooth is found one-third of the length of the finger removed from the tip. Halfway between this tooth and the tip is a fourth, which is so small it can barely be noticed. A pitted groove runs parallel to and a little above the lower margin of the finger from its base to its middle disappearing toward the manus as well as toward the tip. As a whole the lower margin of manus and fixed finger is fairly straight. The concavity which is due to the recurving of the finger is very slight. The dactylus is broad at the base, tapers rapidly at about one-third of its length, and continues from this point to the tip as a

slender and high finger of oval cross-section. The subacute tip is pointing downward. On the occludent margin are a low, large, broad tooth at the base, a high narrow one at about the middle, a third very small one adjoining the second, and two slight tubercles about half way between the third tooth and the tip. The first and second tooth of the dactylus fold to both sides of the first propodal tooth. The upper margin is first gently curved but hooks down sharply to the tip. The carpus is badly eroded but seems to have been conical in shape. The upper distal end carries a spine. The granules of the surface are not quite so densely spaced as on the manus. The short, stout merus has a triangular cross-section, the edges being bluntly rounded. The surface is smooth but around the ventral edge the granules become noticeable. The ischium too is short, stout, and rounded at the edges. Only the posterior flange of the ischium is visible. It is narrow. The part of the sternum adjoining the base of the cheliped is preserved. Its sculpture as a whole is gentle. There is a low, gentle, slightly oblique tubercle at the base of the cheliped. A well marked ridge starting between this tubercle and the last abdominal segment goes around the distal tip of the abdomen. The surface of the sternum is finely punctate.

Dimensions.—Length of palm to the interdigital sinus 29 mm., height of palm at its distal end 24 mm., length of dactylus 26 mm., length of fixed finger 21 mm.

Figured specimen.—In the writer's collection at College Station, Texas.

Locality.—Creek bed directly adjoining the old San Antonio-Nacogdoches trail, 2.85 miles northeast of State Highway 6 (Bryan-Hearne road), Brazos County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Cook Mountain formation, Crockett member, found 2 feet above the lower limonitic limestone ledge, the Moseley limestone of Renick and Stenzel (12, p. 91).

Diagnosis.—The cheliped has about the same size and general outline as the corresponding one in the male *H. rathbunae*. It differs by the prominent and pointed tubercles of the outer manus surface, the almost straight lower margin of manus and fixed finger, the more prominent teeth on both fingers, and the five almost evenly spaced and equal tubercles on the proximal inner margin of the upper surface of the manus. The manus as a whole is more slender and not inflated.

Genus ZANTHOPSIS M'Coy.

Zanthopsis M'COY, *1849*, On the classification of some British fossil crust., Annals and Mag. Nat. Hist., (2) vol. 4, p. 162; type, *Z. leachii* (Desmarest) from the London clay.

ZANTHOPSIS PEYTONI Stenzel, n.sp.

Plate 7, figures 1*a–c*

Z. peytoni STENZEL, *1931*, in B. C. Renick and H. B. Stenzel, Texas Univ., Bull. 3101, pp. 87, 106.

The holotype consists of an eroded and pitted internal mold, the under side of which is largely covered with matrix. The carapace is highly arched from front to back, less so from side to side. It is about one-fourth wider than long. The anterior and frontal margins form almost a semicircle. The frontal margin is about one-fifth as wide as the carapace and is divided into four lobes. The two advanced inner lobes of the frontal margin are separated from each other by a very small sinus and from the outer lobes by sinuses of twice the size. The orbits have, viewed from above, a well rounded, entire, and semicircular upper margin. The outer angle of the orbits is prominent and well advanced. The antero-lateral margins are fairly thin and blunt and carry four evenly spaced spines behind the orbits. These spines are turned upward and outward and increase in size to the posterior so that the last, the lateral one, is the largest. This spine points outward, upward, and backward. The postero-lateral margins are rapidly

converging, thick, convex, and sigmoidal in outline. They end in a backward- and upward-pointing posterior spine. These two posterior spines delimit the posterior margin, where the abdomen is attached.

A broad, medium deep furrow runs from either side of the widest part of the mesogastric region back to the intestinal region, stopping short of the posterior spine. To the front, these furrows lose themselves in shallow, diverging grooves separating the gastric from the branchial regions. Sixteen bosses ornament the surface of the carapace. Each of the branchial regions carries five bosses the other six lie between the branchio-cardiac grooves. Of the five branchial bosses, two lie a little above the postero-lateral margin; of these two the posterior is low and elongate at right angle to the postero-lateral margin, the anterior one is pointed and high-conical, and both are evenly spaced between the lateral and the posterior marginal spines. The third and fourth branchial bosses are situated next to the branchio-cardiac furrow, with the fourth in the angle of the furrow. A fifth branchial boss lies forward and outward from the fourth. Of the six bosses distributed between the branchio-cardiac grooves, four median and elongate ones lie in a row covering the intestinal, cardiac, metagastric, and mesogastric regions respectively. Of these four, the metagastric boss is the largest, and is situated at the highest point of the carapace. Two low and broad bosses occupy each one of the protogastric regions. The hepatic region is indistinct and flattish. The gastric region does not show clear subdivisions.

The underside of the holotype is visible in only a few places. Only part of the merus of the right cheliped shows. It is large, thick and triangular, with rounded edges. Its lower surface is visible; this is finely granulate, the granules increasing in size and number along the lower edge of the merus. The first and second ambulatory legs are oval in cross-section and only sparingly granulate.

The paratype 2 is a fragment of a mold similar to the holotype in size and preservation. Parts of the sternum, the ischium, and the coxa of the right cheliped are preserved. The ischium is short, stout and rounded triangular in cross-section. The sternum is cut by a broad groove which extends in the shape of a wide V from in front of the abdominal tip to the margin anterior to the base of the chelipeds. The median groove of the sternum into which the abdomen fits is deep, narrow, and short, indicating that the specimen probably is a male.

Paratype 3 was prepared from a limestone concretion. The armor of the carapace is preserved to a great extent. It is densely granulate. The first antero-lateral spine is intact and pointed. The other anterolateral spines are broken off at their tips. This specimen shows also parts of the left cheliped. The carpus is very poorly preserved, short, and stout conical in shape. The chela is highly tuberculate and spinous and increases distally in height. There are five tubercles visible on the outside surface of the palm. Of these, three are proximal. Two are large and situated above each other on the proximal end near the manus-corpus joint and the third is smaller and placed more distally and upward. The two distal tubercles of the outside surface are placed one above the other, one very near the lower margin of the palm, the other near the interdigital sinus. The surface of palm is deeply excavated between the three proximal and the two distal tubercles. Two rows of tubercles delimit the narrow upper surface of the palm. There are five or six badly eroded tubercles in each row.

Several specimens have the right chelae preserved. The right chela is similar to the left, but it is not quite so deeply excavated in the middle of the outside surface. The fixed finger is short triangular in outline and compressed. A broad groove runs from the marginal tubercles along the lower margin to the tip. The occludent margin bears three large tubercles or teeth. The dactylus is hooked and

compressed. The occludent margin bears two large tubercles or teeth and the upper margin carries a curved spine near the middle.

Dimensions.—Holotype, male?, width of carapace 84 mm., length of carapace 65 mm., fronto-orbital width 30 mm. Paratype 3, width of carapace 65 mm., length of carapace 51 mm., fronto-orbital width about 24 mm., length of left manus 19 mm., height of left manus at distal end 12 mm. Largest specimen, paratype 5, width of carapace 95 mm., length of carapace 71 mm., fronto-orbital width 35 mm. Paratype 6, width of carapace 72 mm., length of carapace 60 mm., length of right manus to interdigital sinus 33 mm., height of right manus at distal end 25 mm., length of fixed finger 20 mm.

Type specimens.—Holotype and 32 paratypes in the writer's collection at College Station, Texas.

Localities.—Bluff at left bank of Navasota River, at old abandoned iron bridge, southwestern Leon County (type locality); Marquez-Flynn mail route, 5.75 miles east of Marquez; Bald Mound, 4 miles northwest of Centerville; and several other places in Leon County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Mount Selman formation, Weches member, bed *d* of section.

Diagnosis.—This species differs from all other known species of the genus by the pair of spines on the posterior margin. The sculpture of the carapace is similar in *Zanthopsis hendersoniana* (9, p. 53), *Z. errans* (15, p. 115–117, pl. 17, figs. 7–10), and *Z. dufourii* (6, p. 309, pl. 6, figs. 1–3). *Zanthopsis hendersoniana* has bosses merely on the posterior two-thirds of the carapace; in *Z. peytoni*, however, bosses of the protogastric region are quite conspicuous though low. Each of the branchial regions of *Z. hendersoniana*, *Z. errans*, and *Z. dufourii* carries four bosses, the branchial regions of *Z. peytoni* carry five bosses.

The species is named in honor of Mr. F. K. Peyton, who found the holotype.

ZANTHOPSIS PEYTONI var. PARVA
Stenzel, n. var.

This variety is known only from the marly, ferruginous casts of the carapace. On the basis of this material the variety is identical with the typical form, but is much smaller. This in itself may not be sufficient reason to separate the variety from the type species, but for stratigraphic reasons it is advisable, as the variety *parva* can readily be distinguished and is restricted to beds above those containing the typical form.

Dimensions.—Holotype, width of the carapace 51 mm., length of carapace 36 mm. Paratype 2, width of carapace 51 mm., length of carapace 38 mm.

Type specimens.—Holotype and three paratypes in the author's collection at College Station, Texas; one paratype in possession of Dr. B. Coleman Renick, Magnolia Petroleum Company, San Antonio, Texas.

Localities.—L. V. Neyland 240 acre tract, Wm. Mann survey, (type locality); Trinity and Brazos Valley Railroad, 1 mile southwest of Robbins; southeast corner of Concord townsite; and several other places in Leon County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Mount Selman formation, Weches member, bed *g* of section.

Diagnosis.—The variety is distinguished from the typical form by its smaller size.

Family CALAPPIDAE

Genus CALAPPILIA A. Milne-Edwards

Calappilia A. MILNE-EDWARDS, *1873*, in R. de Bouillé, Paléontologie de Biarritz et de quelques autres localités des Basses-Pyrénées, Compte-rendu des travaux du Congrès Scientifique de France (XXXIX^e^ session a Pau), tome 1, Pau, pp. 8–9 (of separate) and pl. 4, figs. 3, 3*a*; type, *C. verrucosa* A. Milne-Edwards from the Rupelian of Biarritz, southwestern France.

CALAPPILIA DIGLYPTA Stenzel, n.sp.

Plate 7, figure 2*a*, *b*

C. diglypta STENZEL, *1931*, in B. C. Renick and H. B. Stenzel, Texas Univ., Bull. 3101, p. 99.

The carapace of the holotype is convex, subglobose, a trifle wider than long, tuberculate, and spinous. Granules are scattered over the carapace, more densely over the posterior part than over the anterior. There is a row of large, crowded granules along the lateral margins. The fronto-orbital region projects a little over the rest of the carapace. It is poorly preserved and the frontal parts are broken off. To judge from their broken base they must have projected beyond the orbits. The orbits are about twice as broad as high (2 by 1 mm.), slant outward and downward, and are separated by a narrow (1.5 mm.) frontal region. The orbital margins are granulate and carry several blunt tubercles, not all of which are preserved. The largest is the post-orbital tubercle which has triangular ground plan and a flat top. There are two more elongate tubercles perserved on the upper margin of the orbits. Each of the two short sinuses intervening between the three tubercles of the superior orbital margin seems to end in a fissure. In this feature the orbits are very similar to those of the genus *Calappa*. The lower orbital margins are not well enough preserved for description. The poorly preserved antero-lateral carapace margins do not carry larger tubercles or spines than the row of granules mentioned above. The postero-lateral margins carry five tubercles and one spine. The first three tubercles are very small and are situated close together on the lateral extremity of the margin. The fourth is medium in size and by its own width removed from the third. The fifth is broken at the base but must have been much larger and is still more removed from the previous one. The spine is the largest, to judge from its base, and more removed from its anterior neighbor than any of the tubercles. A row of large granules lies on the postero-lateral margins overlying tubercles, spines, and intervening sinuses. The posterior margin of the carapace is drawn out into three closely spaced spines, of which only the right one is complete. It is 1.5 mm. long and points horizontally backward and outward. Two very deep and sinuous branchio-cardiac grooves separate the upper surface of the carapace into three distinct parts. There are five median granules or tubercles. A large granule and a large, high, and oblong tubercle are gastric; one small tubercle is urogastric; another small tubercle is cardiac; and a fifth, inconspicuous granule follows. Two medium sized tubercles are placed to the side and a little advanced of the first median gastric granule. Each branchial region carries 12 more or less large tubercles. Of these tubercles, four large ones form an inner row nearly parallel to the deep branchio-cardiac furrows. Between them and the antero-lateral margin are four medium sized tubercles arranged in the fashion of a Y. Two small tubercles lie in front of the latter in the corner between the antero-lateral margin and the end of the furrow. Two more small tubercles lie obliquely in front and inward of the two anterior tubercles of the first enumerated inner row adjoining the branchio-cardiac furrows. All the tubercles in this specimen are worn and therefore bluntly rounded. The paratype has the tubercle tips better preserved. The hepatic regions are narrow and clearly marked off by two branches of the furrows. There are three small granulate tubercles in an oblique row in each hepatic region.

The underside of the carapace is partly exposed on the left side. It shows that the postero-lateral margin is fairly sharp and concavely vaulted over in the region, of the last, large, postero-lateral marginal spine. The underside is highly convex at the lateral extremity of the carapace.

Very indistinct traces of the chelae are visible. They are short and flat and fit under the carapace.

The paratype is a fragment of a carapace, the sculpture being very much the same as in the holotype. However, the tubercles and spines are not worn. The postero-lateral marginal spine is slender,

acute, and nearly 3 mm. long. The inner row of tubercles of the branchial region has steep conical tubercles. The three anterior ones are flat topped to bluntly rounded. The last tubercle is subacute. The largest, the second of the median tubercles, is oblong, a little wider in front than in the back, and bluntly rounded on top.

In the washed residues of the main glauconite bed at Stone City one finds some loose right dactyli of a calappid crab. These dactyli very probably belong to this species.

The species name is derived from the Greek δι (two) and γλυπτος (carved) indicating the two deep branchio-cardiac grooves.

Dimensions.—Holotype, width of carapace 23 mm., length of carapace from base of frontal rostrum to base of the three posterior spines 19 mm., height of carapace from tip of largest median tubercle to lateral margin 6 mm., distance between left and right postorbital tubercle 8.5 mm., length of chelae 9 mm. (?). Paratype, the dimensions of the distances between the different tubercles are the same as in the holotype. It is therefore probable that all other dimensions, such as width of the carapace, were nearly the same as in the holotype.

Type specimens.—Holotype, one paratype, and two loose right dactyli in the writer's collection at College Station, Texas.

Locality.—Above the Houston & Texas Central Railroad bridge, at Stone City, Burleson County, Texas.

Geologic Horizon.—Middle Eocene, Claiborne group, Cook Mountain formation, Crockett member, found in about the middle of the main glauconite sand (bed *b* of the section) at Stone City.

Diagnosis: This species has the deep branchio-cardiac grooves and posterolateral spines of *C. verrucosa* (7, p. 8–9 pl. 4, fig. 3) and *C. hondoensis* (11, p. 7–8, pl. 5, figs. 1, 2). These two features seem to be generic. *Calappilia sexdentata* (8, p. 34–35) has a similar three-spined posterior end. But *C. diglypta* differs from these three species by the much smaller number of its carapace tubercles. In that feature it approaches the genus *Calappa*.

Family CALLIANASSIDAE

Genus CALLIANASSA Leach

Callianassa LEACH, *1814*, Edinburgh Encycl., vol. 7, p. 400; type, *C. subterranea* (Montagu), Recent.

CALLIANASSA BRAZOENSIS Stenzel, n.sp.
Plate 7, figures 3*a–f*

Callianassa brazoensis STENZEL, *1931*, in B. C. Renick and H. B. Stenzel, Texas Univ., Bull. 3101, p. 99.

The holotype consists of a pair of chelae without dactyli found very near each other so that there is little doubt that they belonged to the same individual. The right (larger) chela has a palm of rectangular outline, but the proximal end slants obliquely forward and downward. The cross-section is compressed ovate with a slight concavity along the lower part of the inside surface. The upper and lower margins are straight, parallel, and thin, the lower margin being thinner than the upper. Both margins are ornamented with a thin raised ridge which is highest at the proximal end and disappears near the distal end. The outer surface carries a row of nine widely spaced oblong pits directly above the lower marginal ridge. Two of these nine pits lie on the proximal half of the fixed finger, the other seven on the palm. The long axes of the pits are parallel with the margins and the edges are slightly raised, forming sockets which probably contained bristles. A sharp and narrow ridge runs from the middle upper outer surface of the fixed finger obliquely upward and backward in a sinuous line to about the distal third of the outer surface of the palm. Above this ridge and halfway between the proximal end of the ridge and the interdigital sinus there is a patch of low, irregular tubercles of round and oval outline. A row of four widely spaced socket pits runs parallel with the lower

margin and a little below the above mentioned ridge. The last of these pits is below and little removed from the interdigital sinus. The first pit is near the proximal third of the outside surface of the palm. There is a patch of rough irregular pits in the upper distal corner of the outer surface. The inner surface carries a row of at least 19 distally inclined socket pits directly above and all along the lower margin of palm and fixed finger. A low blunt ridge runs from the middle upper inside surface of the fixed finger slightly obliquely upward and backward to near the lower middle of the inside surface of the palm. A row of nine socket pits runs on the inside surface, parallel with and about 1 mm. below the upper marginal ridge. These pits are oblong and have raised edges. Their long axes are at right angles to the margin of the palm. As both ends of the upper edge of the palm are broken off, it is possible that there were two or three more such pits.

The fixed finger is curved inward and upward and is roughly triangular in cross-section due to the sharp lower margin and the two ridges described above. Its upper, occludent margin carries a row of fine, densely-set granules and two tubercles. One of these tubercles is at the proximal end of the row of granules and the other is about two-fifths of the total length of the finger removed from the proximal end.

The left (smaller) chela of the holotype is about two-thirds the size of the right one. It is slender with thin, straight margins, which converge slightly distally. In all other features—so far as they are preserved—it is similar to the right chela.

Paratype 2 is a left chela of larger size than the right (large) chela of the holotype. It is perhaps the chela of a male, while the holotype belongs perhaps to a female. The paratype 2 is slender, with margins converging noticeably in distal direction. The cross-section is the same as above. Near the upper margin on the inside surface, there are 12 oblong bristle pits instead of nine as in the holotype. There are 22 bristle pits along the lower margin of the inside surface. A row of seven bristle pits runs along the lower margin of the outside surface. There is a row of six bristle pits on the outside surface of the palm below the oblique ridge. Except for the number of pits in the different rows, this paratype is very similar to the first described chela.

Paratype 5 consists of a right (large) palm, some armor plate fragments, and fragments of a finger. The row of socket pits below the upper margin on the inside surface of the palm has ten distally inclined pits. There are no rough pits in the upper distal corner of the outside surface of the palm. A little away from this corner there is, however, a group of low oblong tubercles which is not found in the other types. Other features are similar to the first described chela.

Dimensions.—Holotype, right (larger) chela: length of palm 9.5 mm., length of fixed finger 4 mm., height of palm 6.5 mm., greatest thickness of palm 3.2 mm.; left (smaller) chela: length of palm 6.5 mm., height of palm at proximal end 4.5 mm., at distal end 4 mm., greatest thickness of palm 2.1 mm. Paratype 2, left chela, length of palm 13 mm., length of fixed finger 5 mm. (tip is missing), height of palm at proximal end 8 mm., at distal end 7.1 mm., greatest thickness of palm 4.1 mm. Paratype 3, right chela, length of palm 10.3 mm., height of palm at proximal end 6.7 mm., at distal end 6.2 mm., greatest thickness of palm 3.2 mm. Paratype 5, right chela, length of palm 9.7 mm., height of palm at proximal end 7.7 mm., at distal end 7 mm., greatest thickness of palm 3.6 mm.

Type specimens.—Holotype, consisting of a pair of chelae, and eleven paratypes, consisting of eight loose chelae and three pairs, in the writer's collection at College Station, Texas.

Locality.—Little Brazos River, Brazos County, Texas.

Geologic Horizon.—Middle Eocene,

Claiborne group, Cook Mountain formation, Crockett member.

Diagnosis.—This species is characterized among the numerous species of this genus by the four rows of socket pits, their number, and the shape of the manus.

CALLIANASSA WECHESENSIS Stenzel, n. sp.

Plate 7, figures 4*a*, *b*

The holotype is a somewhat weathered but nearly complete right chela with some fragments of unidentifiable part of the limbs. The palm is of rectangular outline but shorter than in *Callianassa brazoensis*. The proximal end of the manus is much weathered and appears nearly vertical and straight. The cross-section is compressed ovate with a slight concavity along the lower part of the inside surface, it is very similar to the cross-section of *C. brazoensis*. The upper and lower margins are straight, parallel, and very thin, the lower margin being thinner than the upper one. Both margins appear to be ornamented with a thin raised ridge. Directly below the upper margin and directly above the lower margin of the inner surface there is a row of pits. The pits of the lower row are more closely spaced and reach the tip of the fixed finger. Near the interdigital sinus on the inner surface there is a group of low and round tubercles of varying sizes. The margin of the palm around the manus-dactylus joint is ornamented with many raised granules. The fixed finger is slender and curves inward and upward. The dactylus is rapidly tapering and curves downward. It carries six socket pits directly below its upper margin on the inner surface. The two proximal pits are close to each other; the rest are wider and more evenly spaced. The outer surface of the manus and dactylus are embedded in matrix.

The paratype 2 is imbedded in the same piece of matrix as the holotype and is a right manus also, but is slightly smaller. The much weathered outer surface permits observation of the following additional features: A low and rounded ridge runs from the upper margin of the outer surface of the fixed finger obliquely and slightly sinuously upward and backward to about the distal fourth of the outer surface of the palm. This ridge carries a socket pit at the base of the fixed finger. Two socket pits lie directly above the lower margin on the proximal part of the fixed finger. A group of low oblong tubercles lies in the corner between this ridge and the interdigital sinus.

Dimensions.—Holotype, right chela, length of palm 9 mm., length of fixed finger (tip broken off) 3.7 mm., greatest height of palm 6.3 mm., thickness of palm 2.5 mm., length of dactylus 5.1 mm. Paratype 2, right chela, length of palm 8.8 mm., greatest height 6 mm. Paratype 3, left chela, length of palm 9.7 mm., length of fixed finger (tip broken off) 3.2 mm., greatest height of palm 7.2 mm. Paratype 4, height of palm 7.1 mm., thickness of palm 2.8 mm.

Type specimens.—Holotype and three paratypes in the writer's collection at College Station, Texas.

Locality.—Marquez-Flynn mail route, 5.75 miles east of Marquez, Leon County, Texas.

Geologic horizon.—Middle Eocene, Claiborne group, Mount Selman formation, Weches member, in bed *d* of section.

Diagnosis.—This species is easily distinguished from the preceding one by its nearly vertical and straight proximal end of the palm, its shorter palm, and the group of tubercles near the interdigital sinus on the inner surface. The row of socket pits directly below the upper margin of the inner surface is much nearer to the margin in this species than in *Callianassa brazoensis*.

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OSTRACODA OF THE GENERA *MONOCERATINA* AND *ORTHONOTACYTHERE* FROM THE CRETACEOUS OF TEXAS

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ABSTRACT

The shell characters of the genera *Monoceratina* and *Orthonotacythere* are described in detail. The probable evolution of the hinge teeth in the family Cytheridae from a simple hinge structure like that of *Monoceratina* is outlined. It is suggested that *Monoceratina* may be the direct ancestor from which the subfamilies Cytherurinae, Loxoconchinae, Bythocytherinae, and possibly the Cytherinae were derived, and that since this genus does not appear to be a likely ancestor for the other subfamilies of the family Cytheridae, this family may be, as at present arranged, polyphletic. Nine species of *Monoceratina* (five new), and four species of *Orthonotacythere* (three new) are described and figured.

In 1928, Roth described the genus *Monoceratina*,[1] placing it in the family Primitiidae. The type species, *M. ventrale* Roth,[2] was collected from strata of Pennsylvanian age in Oklahoma. Through the courtesy of R. V. Hollingsworth, graduate student in the Department of Geology of the University of Oklahoma, the writer has received specimens of *M. ventrale* from the type locality.

In a recent number of this journal,[3] the writer made a detailed analysis of the shell structure of the genus, demonstrating its affiliation with the family Cytheridae, and stating that the genus seemed to have reached its greatest development in Upper Cretaceous time. Several species of *Monoceratina* have been described by various authors under the names *Cythere*, *Cytheropteron* and *Cytherura*, from beds of Cretaceous age in many parts of the world. In the same paper, the writer described the new genus *Orthonotacythere*,[4] and stated the belief that this new genus was derived from *Monoceratina*.

The two genera are remarkably similar in the outline or form of the shell and in surface sculpture. Both are characterized by a quadrate to ovate outline, by a long, straight dorsal margin, and by a short, narrow, compressed caudal process situated at or near the postero-dorsal angle.

The surface in both genera is characteristically marked by pits or reticulation, and in some species, by

[1] Roth, R. A., *Monoceratina*, A new genus of Ostracoda from the Pennsylvanian of Oklahoma: *Jour. Paleontology*, vol. 2, p. 15, 1928.

[2] Roth, R. A., *Op. cit.*, p. 16, fig. 1.

[3] Alexander, C. I., Shell structure of the genus *Cytheropteron*, and species from the Cretaceous of Texas: *Jour. Paleontology*, vol. 7, p. 202, 1933.

[4] Alexander, C. I., *Op. cit.*, p. 199.

the addition of tubercles or spines. Species of *Monoceratina*, with but few exceptions, bear a stout, horn-like spine, which is situated, as a rule, at or near the ventral margin and slightly behind the middle. In some species of *Monoceratina*, and in most species of *Orthonotacythere*, this spine is replaced by a strongly elevated, rounded, tubercle. In species characterized by a tuberculate surface, this tubercle is larger and more prominent than the others.

The shell of *Monoceratina* is characteristically divided, by a distinct, median vertical sulcus, into two approximately equal lobes. The straight dorsal margin and the median vertical sulcus are characters seen in genera of the Paleozoic families Primitiidae and Beyrichiidae, and doubtless account for Roth's assignment of *Monoceratina* to the former. These characters, in fact, may indicate the derivation of *Monoceratina* from some member of one of these families. The presence of the distinct caudal process, a character seen in several genera of the Cytheridae, and unknown in either the Primitiidae or Beyrichiidae, definitely places *Monoceratina* in the former group, instead of in one of the latter.

The fact that species of *Orthonotacythere* exhibit a faint median vertical sulcus is believed to be significant evidence regarding the relationship of *Orthonotacythere* and *Monoceratina*.

The most important evidence, however, is seen in the hinge structure of the two genera. The hinge of *Monoceratina* is simple, consisting of a narrow bar in the left valve, which fits into a shallow groove in the dorsal margin of the right valve. This structure is modified in *Orthonotacythere*, by the development of crenulations on the bar of the left valve, and the development of a small tooth at each end of the hinge line in the right valve, with corresponding sockets in the left. The teeth each bear several cusps. Most genera of the family Cytheridae have a narrow bar in the hinge margin of the left valve, and the development of crenulations on this bar is a common tendency in these genera. In all the Cretaceous and Tertiary species of *Loxoconcha* examined by the writer, for example, the hinge-bar is simple, but Müller states that in some Recent species it is crenulate.[5] The hinge bar in most Cretaceous species of *Cytheridea* is simple, but in some Upper Cretaceous species, and in many Tertiary and Recent species, it is crenulate. The writer has specimens of a Recent species of *Brachycythere*, collected from Manila Bay, Philippine Islands, in which the hinge bar shows faint crenulations.

It seems probable that the simplest type of hinge tooth is a simple, narrow, short, ridge-like tooth, and species of *Orthonotacythere* with hinge teeth of this type will probably be discovered in rocks of Triassic or Jurassic age, when the microfaunas of these periods have been revealed by thorough studies. It is probable that the development of crenulations

[5] Müller, G. W., Flora und Fauna des Golfes von Neapel, Monogr. 21, Ostracoda, p. 342, 1894.

or cusps on the hinge teeth, as on the hinge bar, is a later development from an originally simple condition.

Knob-like teeth, such as are seen in *Cythereis*, *Brachycythere*, and many other genera of the family Cytheridae, might conceivably be developed from the crenulate type by either the fusion of the separate cusps, or more likely, by the exaggeration of one of the cusps and the suppression of the others. It is significant, in this connection, that *Cythereis triplicata* (Roemer), from the Lower Cretaceous, Barremian, of Germany, exhibits crenulate hinge-teeth, like those of *Orthonotacythere*. The hinge-bar of the left valve, however, is not crenulate. Some species of *Cythereis* have a crenulate posterior tooth and a knob-like anterior tooth, although in most members of the genus, both the anterior and posterior teeth are knob-like. Some genera of the family Cytheridae, for example *Cytheropteron* and *Xestoleberis*, still retain crenulate teeth like those of *Orthonotacythere*.

The family Cytheridae, as at present arranged, may be polyphyletic. It seems probable that *Monoceratina* is the ancestor from which the genera belonging to the subfamilies Cytherurinae, Loxoconchinae, and Bythocytherinae and perhaps the Cytherinae were derived. This genus does not, however, appear to be a likely ancestor for the other subfamilies of the family Cytheridae. If this conclusion is correct, the subfamilies of the family Cytheridae should be either raised to family rank, or grouped under two or more new family names.

The proof or disproof of these conclusions must await a more detailed knowledge of the Ostracoda of the Permian, Triassic, Jurassic and lowermost Cretaceous. Doctor A. Franke, of Arnstadt, Germany, is at present engaged in the investigation of the Ostracoda of the lower Jurassic of Germany.

The genera *Monoceratina* and *Orthonotacythere* are of special interest to the paleontologist, not only because the former is the earliest known member of the family Cytheridae, but also because they are the only described genera of this family represented by fossil species from the Cretaceous which are not also represented in the Recent seas.

Monoceratina appears to range from Pennsylvanian to Oligocene. The species described by Speyer[6] under the name *Cythere undulata*, from the Oligocene of Germany is undoubtedly a member of this genus. No species which seem to be referable to *Monoceratina* have been recorded in the literature from beds of Eocene age, or from beds younger than the Oligocene. Eocene species will, of course, be found eventually. Several species have been described, under the generic names *Cythere* and *Cytheropteron*, from the Upper Cretaceous of Europe. Four of these and several new species have been found in the Upper Cretaceous of Texas. One species, represented by a

[6] Speyer, O., Die Ostracoden der Casseler Tertiarbildungen, p. 33, pl. 4, fig. 5, Cassel, 1863.

single individual, has been found in the writer's collections from the Lower Cretaceous of Texas.

The known species of *Orthonotacythere* occur exclusively in strata of Upper Cretaceous age. It is the writer's conviction, however, as previously indicated, that species of this genus will eventually be found in strata of Permian, Triassic, Jurassic or Lower Cretaceous age.

One species of *Orthonotacythere* has been found to occur in the Midway formation, which is commonly regarded as the basal division of the Eocene in Texas. Recently, however, evidence has been published indicating that the Midway should be regarded as Upper Cretaceous in age rather than Eocene, and correlating it with the Danian of Europe.[7] Before the publication of this evidence, it was generally believed that there were no strata of Danian age in the western hemisphere, and that Danian time was represented in the long erosional interval which was supposed to have intervened between the deposition of the Navarro and Midway formations. The fact that several species of both Ostracoda and foraminifera[8] are common to the two formations seems to indicate that the hiatus represented by the unconformity is not so great as has been commonly supposed.

In Texas, representatives of the genera *Monoceratina* and *Orthonotacythere* occur most commonly in the Austin chalk and the overlying Taylor clays, and their stratigraphic equivalents. Only two species, *Monoceratina umbonata* (Williamson) and *Orthonotacythere hannai* (Israelsky), the former represented by a single specimen, have been observed in the Navarro formation.

DESCRIPTION OF SPECIES

Order OSTRACODA Latreille

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird, 1850

Genus MONOCERATINA Roth, 1928

MONOCERATINA PEDATA (Marsson)

Cythere pedata MARSSON, *1880*, Mittheil. naturwiss. Verein von Neu-Vorpommern und Rugen in Greifswald, p. 46, pl. 3, fig. 16*c*.

Cytheropteron pedatum JONES and HINDE, *1889*, Suppl. Monogr. Cret. Entom. Engl., Irel., Paleontogr. Soc. London, p. 38, pl. 4, figs. 33–35.

Cytherura spooneri ISRAELSKY, *1929*. Ark. Geol. Survey, Bull. 2, p. 6, pl. 4A, fig. 7.

Monoceratina pedata ALEXANDER, *1933*, Jour. Paleontology, vol. 7, no. 2, p. 203, pl. 27, fig. 15.

This striking and easily recognizable species occurs in the lower two-thirds of the Taylor, and in its stratigraphic equivalents in Texas, and is most frequently represented in the chalky facies, such as the Gober and Annona chalks of the northeast Texas section. Israelsky describes the species as occurring in the Brownstown and Ozan clays of Arkansas, and the writer has found it to be even more common in the Annona and Saratoga chalks of the same region.

[7] Scott, G., Etudes stratigraphiques et paléontologiques sur les terrains crétacés du Texas: *Thèse Doctorat, Univ. de Grenoble*, p. 114, 1926.

Scott, G., A new correlation of the Texas Cretaceous: *Am. Jour. Sci.*, ser. 5, vol. 12, no. 71, p. 159, 1926.

[8] Plummer, Helen Jeanne, Foraminifera of the Midway formation of Texas: *Texas Univ., Bull.* 2644, p. 20, 1926.

MONOCERATINA PEDATA var. LAEVIS (Marsson)

Cythere pedata var. *laevis* MARSSON, *1880*, Mittheil. naturwiss. Verein von Neu-Vorpommern und Rugen in Greifswald, p. 45, pl. 3, figs. 16 *a*, *b*.

This variety differs from the typical, reticulate form of the species in having a smooth, glassy-appearing surface. Some individuals bear a few fine, scattered spines.

In the Texas section, this variety has the same stratigraphic range as the typical form of the species, but is very rare.

MONOCERATINA ACANTHOPTERA (Marsson)

Plate 8, figure 6

Cythere acanthoptera MARSSON, *1880*, Mittheil. naturwiss. Verein von Neu-Vorpommern und Rugen in Greifswald, p. 45, pl. 3, fig. 14.

Shell small, quadrate in outline. Dorsal margin straight. Ventral margin nearly straight, slightly convex downward. Dorsal and ventral margins subparallel, diverging slightly posteriorly. Ventral margin curves broadly upward at posterior end to the short, compressed caudal process. Anterior and posterior ends of shell compressed, central portion very strongly convex, with greatest width at ventral margin. A distinct, median vertical sulcus divides the carapace into two subequal lobes. The posterior lobe bears a short, hornlike spine at the ventral margin. Surface of valves smooth.

Length of plesiotype 0.6 mm., height 0.3 mm., width 0.5 mm.

Both the lateral horns and the caudal process were broken from the specimen figured here, and while other specimens were found in which these structures were preserved, the individual selected for illustration was the most nearly complete and best preserved representative of the species found in the writer's collections.

M. acanthoptera is very similar in general appearance to *M. longispina* (Bosquet)[9] but is smaller, and lacks the distinct longitudinal ridges which mark the ventral surface of that species.

M. acanthoptera is a rare form, occurring throughout the Taylor formation and its equivalents in all parts of the state.

Plesiotype.—No. 0–2498.1 Alexander Collections, collected at an exposure of upper Taylor clays on the right bank of Onion Creek near the bridge at Moore and Berry's crossing, 8.5 miles in a straight line southeast of the State Capitol in Austin, Travis County, Texas.

MONOCERATINA PARALLELA Alexander, n.sp.

Plate 8, figure 3

Shell small, elongate, quadrate in outline. Dorsal and ventral margins straight and parallel. Anterior end evenly rounded. Posterior end obliquely truncated, with acute postero-dorsal angle; postero-ventral border and caudal process compressed. Valves, with exception of compressed terminal portions, strongly convex, widest at ventral margin. A shallow, median vertical sulcus divides the carapace into two subequal lobes. The posterior lobe bears a short, hornlike spine at the ventral margin.

Length of holotype 0.6 mm., height 0.26 mm., width 0.4 mm.

This species is somewhat similar in appearance to *O. acanthoptera* (Marsson) and *O. longispina* (Bosquet), but is distinctly narrower and more elongate in side view, has a straight rather than a convex ventral margin, and is somewhat less strongly convex in dorsal view.

O. parallela has been found only in outcrops of upper Austin and lower Gober chalk in north Texas. It is usually represented by only one or two specimens at each locality where it has been observed.

Holotype.—No. 0–24105.1 Alexander Collections, collected at an exposure of upper Austin chalk in a deep road cut

[9] Bosquet, J., Entomostracés fossiles du terrain crétacé de Duché Limbourg: *Mém. de la Comm. pour la descript. de la carte géol. de la Neerlande*, vol. 2, p. 86, pl. 6, fig. 7, 1854.

on the Dallas-Sherman highway, at the southern edge of the city of McKinney, Collin County, Texas.

MONOCERATINA MONTUOSA (Jones)

Plate 8, figure 5

Cythere (Cythereis) montuosa JONES, *1875*, Syst. Lists, Belfast Nat. Field Club, vol. 1, Appendix 3, pp. 81, 82.

Cytheropteron cuspidatum var. *montuosa* JONES and HINDE, *1890*, Suppl. Monogr. Cret. Entom. Eng., Irel., Paleontogr. Soc. London, p. 38, pl. 3, figs. 14–16.

Carapace elongate, quadrate in side view. Dorsal margin straight. Anterior half of ventral margin straight, parallel to dorsal margin; posterior half curves gently upward toward the short, compressed, acute caudal process at the postero-dorsal angle, and is finely serrate or denticulate. Anterior end rounded along lower half, straight along upper half, and forming a right angle with the straight dorsal margin. Anterior margin bears a thickened marginal rim, which is densely beset with short, sharp spines. Anterior and posterior portions of carapace compressed, central portion moderately convex. A broad, shallow, median vertical sulcus divides the inflated central portion into two subequal lobes. The ventro-lateral region of the valve bears a short, low, finely serrate, longitudinal ridge. Three short spines are situated at approximately equal intervals along the dorsal edge of the valves. Two other spines are situated slightly below the median longitudinal line of the valves, a short one on the anterior lobe, and a long one, tapering and needle-like, on the posterior lobe. Surface of valves smooth, except for a group of small, deep pits around the base of the anterior lateral spine, and a few scattered nodes or small tubercles.

Length of plesiotype 0.7 mm., height 0.28 mm.

M. montuosa has been recognized in the writer's collections from the Annona and Gober chalks of northeast Texas only.

Plesiotype.—No. 0–2499.1 Alexander Collections. Collected at an exposure of lower Gober chalk in a roadside ditch along the north side of the road which leads eastward from Van Alstyne to the Whiteright-Blue Ridge highway, at a point 3.7 miles east of Van Alstyne, Grayson County, Texas.

MONOCERATINA UMBONATA (Williamson)

Plate 8, figure 9

Cytherina umbonata WILLIAMSON, *1847*, Mem. Manchester Lit., Phil. Soc., vol. 8, p. 79, pl. 4, fig. 78.

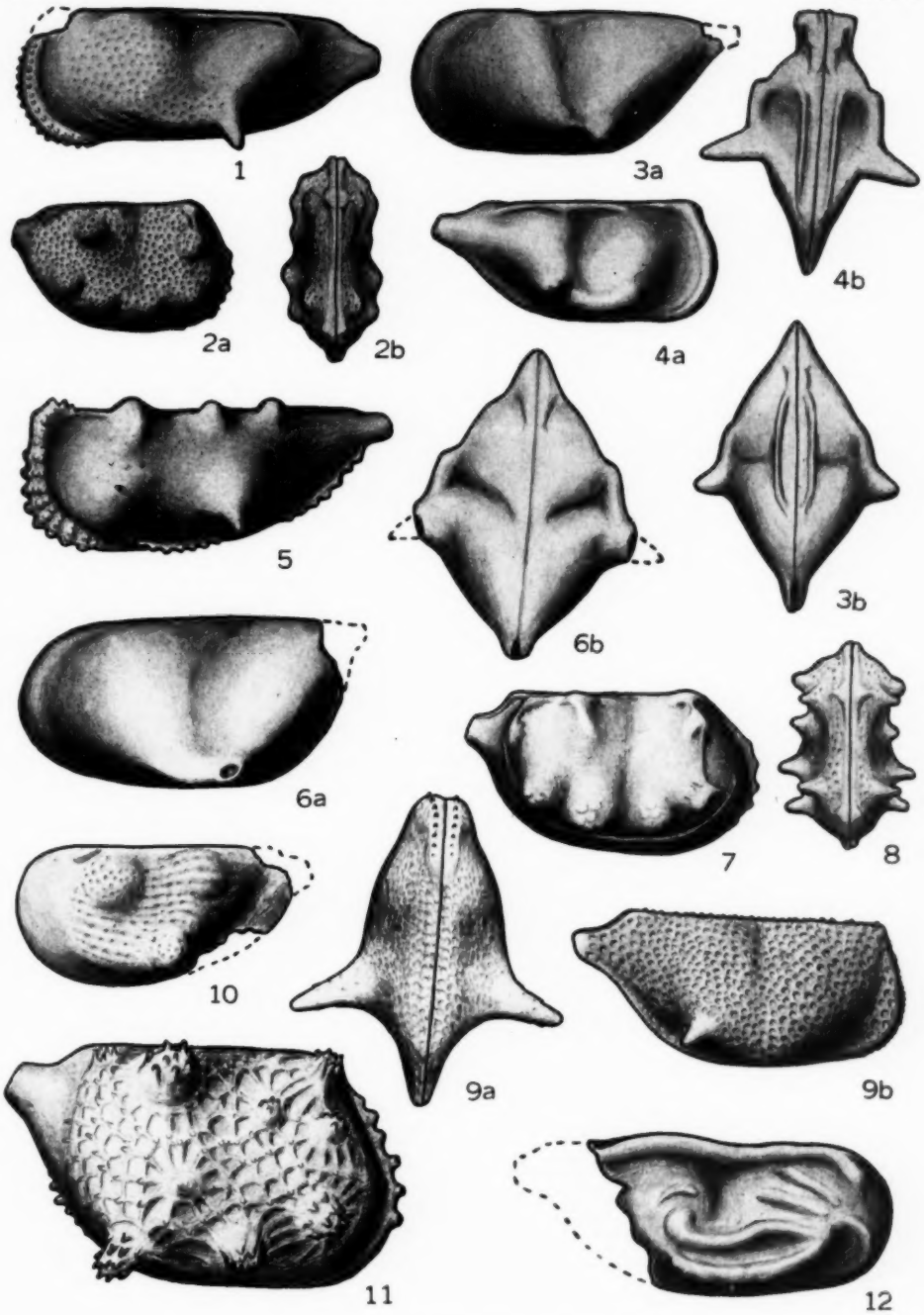
Cythere umbonata JONES, *1849*, Monogr. Cret. Entom. Eng., Paleontogr. Soc. London, p. 12, pl. 2, figs. 3 *a–g*; MARSSON, *1880*, Mittheil. naturwiss. Verein von Meu-Vorpommern und Rugen in Greifswald, p. 45, pl. 3, fig. 15.

Cytheropteron umbonatum JONES, *1870*, Geol. Mag., pp. 74, 76; JONES and HINDE, *1890*, Suppl. Monogr. Cret. Entom. Eng., Irel., Paleontogr. Soc. London, p. 40, pl. 1, figs. 21–26.

EXPLANATION OF PLATE 8

FIGS. 1—*Monoceratina semiornata* Alexander, n. sp.; holotype, lateral view of left valve.
2, 8—*Orthonotacythere scrobiculata* Alexander, n. sp. 2, holotype, *a*, right valve view, *b*, dorsal view. 8, Paratype, dorsal view.
3—*Monoceratina parallela* Alexander, n. sp.; holotype, *a*, left valve view, *b*, dorsal view.
4—*Monoceratina nitida* Alexander, n. sp.; holotype, *a*, right valve view, *b*, dorsal view.
5—*Monoceratina montuosa* (Jones); plesiotype, lateral view of left valve.
6—*Monoceratina acanthoptera* (Marsson); plesiotype, *a*, left valve view, *b*, dorsal view.
7—*Orthonotacythere polita* Alexander, n. sp.; holotype, right valve view.
9—*Monoceratina umbonata* (Williamson); plesiotype, *a*, dorsal view, *b*, right valve view.
10—*Monoceratina trinodosa* Alexander, n. sp., holotype, lateral view of left valve.
11—*Orthonotacythere cristata* Alexander, n. sp.; holotype, lateral view of right valve.
12—*Monoceratina jugosa* Alexander, n. sp.; holotype, lateral view of right valve.

All figures ×75.



Alexander, Cretaceous ostracodes

Carapace elongate, subovate in side view, highest at about middle. Dorsal margin straight. Ventral margin gently and evenly convex downward. Anterior end slightly narrowed, obliquely rounded. Posterior end tapering to short, acute caudal process at postero-dorsal angle. Anterior and posterior ends of shell somewhat compressed, central portion moderately convex, widest near ventral margin. A shallow, median vertical sulcus which extends downward from the dorsal margin to slightly below the middle of the valves, divides the shell into two subequal lobes, the posterior being slightly more strongly inflated than the anterior. The posterior lobe bears a long, stout, horn-like spine near the ventral margin. Surface of valves finely and strongly reticulate.

Length of plesiotype 0.65 mm., height 0.27 mm., width 0.5 mm.

This species is somewhat similar in general appearance to *M. pedata* (Marsson), but may be readily differentiated by the distinct division of the shell into lobes by a median vertical sulcus, the narrower anterior end, and the distinctly finer reticulation of the valve surfaces.

M. umbonata is very rare in the Texas Cretaceous. A few specimens have been found in collections from the Taylor formation and its stratigraphic equivalents, and a single individual has been collected at an exposure of lower Navarro clays on Onion Creek, at Jones' Crossing on the Austin-Bastrop highway.

Plesiotype.—No. 0–24101.1 Alexander Collections, collected at an exposure of lower Annona chalk, at the southern edge of the town of White Rock, Red River County, Texas.

MONOCERATINA SEMIORNATA
Alexander, n. sp.
Plate 8, figure 1

Carapace in side view narrow, elongate, highest at anterior end, tapering posteriorly. Dorsal margin straight. Ventral margin nearly straight, very gently convex downward except for slight sinuosity near anterior end. Anterior end broadly and obliquely rounded, finely denticulate, and bearing a slightly elevated, narrow, marginal rim. Posterior end tapering abruptly to a short, rather blunt caudal process slightly above the middle. Anterior and posterior ends of carapace somewhat compressed, central portion strongly inflated. A shallow, vertical sulcus which extends downward from the dorsal margin to slightly below the level of the median longitudinal line of the valve, divides the carapace into two subequal and dissimilar lobes. The anterior lobe is rounded and evenly inflated, while the posterior is strongly inflated only at the ventral margin. The posterior lobe bears a long, needle-like, laterally projecting spine at the ventral margin, just behind the lower end of the median vertical sulcus. The antero-ventral region of the anterior lobe bears two to three low, curved ridges, and the surface of this lobe is finely pitted. The posterior lobe bears a low, rounded ridge along the dorsal border. The posterior half of the valve surface is smooth.

Length of holotype 0.67 mm., height 0.26 mm.

This peculiarly ornamented species is a very rare form occurring in the upper Austin chalk in south Texas.

Holotype.—No. 0–24102.1 Alexander Collections, collected at an exposure of upper Austin chalk, in the west bank of Little Walnut Creek near the bridge which crosses the creek on the Austin-Manor highway, 3.9 miles from the corner of East Avenue and 22nd Street in Austin, Travis County, Texas. The collection was made from a yellowish layer of calcareous clay in the lower part of the stream bank.

MONOCERATINA NITIDA Alexander, n. sp.
Plate 8, figure 4

Carapace small, elongate, quadrate in outline. Dorsal margin straight. Ventral margin straight and parallel to dorsal margin in anterior two-thirds of length,

then turning abruptly upward to the short, blunt caudal process at the postero-dorsal angle. Anterior end evenly rounded, bearing a strongly elevated, narrow, marginal rim. Anterior and posterior ends of carapace compressed, central portion moderately inflated, with greatest width at ventral margin. Ventro-lateral edge of inflated portion of each valve bears a narrow, strongly elvated, slightly curved ridge, which bears a strong, laterally projecting, hornlike spine at its posterior end. A shallow, median vertical sulcus, which extends downward from the dorsal margin and terminates just above the middle of the ventral ridge, divides the shell into two subequal lobes. Surface of valves smooth.

Length of holotype 0.52 mm., height 0.22 mm., width 0.41 mm.

M. nitida occurs as a rare species in exposures of Gober chalk in north and northeast Texas.

Holotype.—No. 0–24100.1 Alexander Collections, collected at an exposure of lower Gober chalk in a roadside ditch along the north side of the road which leads eastward from Van Alstyne to the Whiteright-Blue Ridge highway, at a point 3.7 miles east of Van Alstyne, Grayson County, Texas.

MONOCERATINA JUGOSA Alexander, n. sp.

Plate 8, figure 12

Carapace in side view elongate, highest at middle. Dorsal margin nearly straight, slightly irregular. Ventral margin gently convex downward. Anterior end rounded. Posterior end compressed, tapering. Central portion of valves strongly convex. A deep, median vertical sulcus, which extends downward from the dorsal margin to about the middle of the valve, divides it into two subequal lobes. The surface is ornamented by six narrow, strongly elevated ridges which have somewhat irregular, sinuous courses, but are longitudinally disposed. One of these ridges extends along the dorsal border of the valve. The other five arise at a common point a short distance behind the middle of the anterior border of the shell. One of these curves forward and downward to join the anterior margin at the antero-ventral angle, where it becomes obsolete. Two short ridges extend somewhat obliquely upward and backward from their point of origin, and terminate at the median vertical sulcus; these two ridges diverge slightly posteriorly, the upper one ending just below the dorsal marginal ridge. Two long ridges, one slightly below the median longitudinal line of the valve and the other near the ventral margin, terminate posteriorly at a point about one-third of the length of the shell from the posterior end; the upper ridge extends straight backward for a short distance, then bends abruptly downward to pass below the lower end of the median vertical sulcus, and terminates posteriorly in a blunt, hook-like, upward curve; the lower ridge is gently and evenly arcuate or convex downward. A small, elongate, rounded node or tubercle is situated just above the posterior end of the upper one of the two long ridges.

Length of holotype 0.7 mm. (estimated), height 0.25 mm.

This striking species is represented in the writer's collections by a single, incomplete right valve.

Holotype.—No. 0–24103.1 Alexander Collections, collected at an exposure of Gober chalk in a roadside ditch north of the Paris-Bonham highway, 2.2 miles west of Petty, Lamar County, Texas.

MONOCERATINA TRINODOSA Alexander, n. sp.

Plate 8, figure 10

Shell elongate, subquadrate in outline. Dorsal margin straight. Ventral margin gently convex downward. Anterior end evenly rounded, compressed. Posterior end compressed, tapering to caudal process at postero-dorsal angle. Shell convex, widest and distinctly tumid at ventral margin. A broad, shallow, median vertical sulcus which extends downward from the dorsal margin and ends a short distance above the inflated ventral region

divides the carapace into two subequal lobes. Each valve bears three prominent, rounded, knob-like tubercles. The most strongly elevated one is borne on the inflated ventral portion of the valve, slightly behind the lower end of the median vertical sulcus. The other two are near the dorsal margin, one just anterior and the other posterior to the median vertical sulcus. The surface of the shell is marked by numerous low, narrow, obscure, longitudinal ridges, the furrows between these ridges each containing a row of shallow, slightly elongated pits.

Length of holotype 0.55 mm., height 0.27 mm.

This species, like the preceding, is represented in the writer's collections by a single incomplete valve. It is especially noteworthy, however, as it is the only recorded occurrence of a representative of this genus in strata of Lower Cretaceous age.

Holotype.—No. 0–2338.1 Alexander Collections, collected at an exposure of upper Weno limestone and marl in a roadside ditch 0.3 miles south of the bridge which crosses Sycamore Creek on the Fort Worth-Mansfield highway, near the Glen Garden County Club, Fort Worth, Tarrant County, Texas.

Genus ORTHONOTACYTHERE Alexander, 1933

ORTHONOTACYTHERE HANNAI (Israelsky)

Cytheridea (?) *hannai* ISRAELSKY, *1929*, Ark. Geol. Survey, Bull. 2, p. 12, pl. 2A, fig. 10.
Cytheropteron hannai ALEXANDER, *1929*, Texas Univ., Bull. 2907, p. 105, pl. 9, fig. 16.
Orthonotacythere hannai ALEXANDER, *1933*, Jour. Paleontology vol. 7, no. 2, p. 200, pl. 25, fig. 1; pl. 26, fig. 6; pl. 27, fig. 14.

This species was originally described from the Ozan clay of Arkansas, which is correlative with the Taylor clays underlying the Wolfe City sand or that stratigraphic level in the Upper Cretaceous of Texas. Representatives of the species are very rare in the Taylor and its stratigraphic equivalents in Texas, and are somewhat more common in the overlying Navarro clays. Specimens from the Navarro are, as a rule, slightly larger than those from the Taylor and from the Ozan of Arkansas, but the proportions of the carapace and the arrangement of the surface tubercles are exactly similar, and the two forms must be regarded as specifically identical.

A very similar and closely related form occurs in the Midway formation, and two somewhat similar species have been found in the Taylor. These species will be described below.

ORTHONOTACYTHERE CRISTATA

Alexander, n. sp.

Plate 8, figure 11

The proportions and shape of the shell, and the arrangement of the surface tubercles of this species are exactly the same as in *O. hannai*. The tubercles, however, are more strongly elevated, and each bears a crest of several short spines. The surface of the valves between the tubercles is marked by distinct, but low ridges, forming a coarse reticular pattern. Short, blunt spines are situated at the points of junction of the reticular ridges. Around the bases of the strongly elevated, crested tubercles, the ridges have a distinctly radial arrangement.

Length of holotype 0.73 mm., height 0.42 mm.

The large surface tubercles of *O. hannai* bear smaller tubercles, which in some individuals are so strongly elevated that they might be regarded as forming a crest of short spines, similar to that which characterizes *O. cristata*. The two species are obviously closely related, but may be differentiated by the coarser reticulation which marks the valve surface of the present species, the presence of the short spines at the points of junction of the reticular ridges, and the distinctly radial arrangement of the ridges around the bases of the tubercles.

O. cristata occurs somewhat more frequently in the lower Midway than in the upper portion of the formation.

Holotype.—No. 0–24104.1 Alexander Collections, collected at an exposure of upper Midway clay, in a roadside ditch on the Austin-Lockhart highway, on the north slope of a large tributary to Plum Creek, 0.9 mile north of the Missouri, Kansas, and Texas station in Lockhart.

ORTHONOTACYTHERE SCROBICULATA
Alexander, n. sp.
Plate 8, figures 2, 8

Shell small, quadrate in outline. Dorsal margin straight. Ventral margin slightly convex downward, curving abruptly upward posteriorly to the short, blunt, compressed caudal process at the postero-dorsal angle. Anterior end broadly and somewhat obliquely rounded, with narrow, compressed border bearing four to five short, sharp marginal teeth. Carapace strongly compressed, widest and slightly inflated at ventral margin. A distinct vertical sulcus, slightly anterior to the middle, divides the carapace into two subequal lobes. Surface of valves finely and strongly pitted, and bearing seven distinct, strongly elevated, rounded tubercles on each valve. Four of these tubercles form a roughly longitudinal row near the ventral margin; one is near the ventral edge of the anterior lobe of the valve, another at the lower end of the vertical sulcus, and the other two on the posterior lobe. The two posterior tubercles are more strongly elevated than the anterior ones. The antero-dorsal angle is marked by a small, smooth, anterior cardinal tubercle, and a short distance below it there is a larger tubercle, connected to it by a low, narrow ridge. A large, round tubercle is situated just above the middle of the posterior lobe. In addition to these seven prominent tubercles, there is a small, obscure, posterior cardinal tubercle at the posterior end of the hinge margin.

Length of holotype 0.42 mm., height 0.23 mm., width 0.19 mm.

This species is somewhat similar to *O. hannai* in appearance, but differs in its smaller size, in being much more strongly compressed, and in the distinctly different arrangement of the surface tubercles.

O. scrobiculata is somewhat variable with respect to the degree of elevation of the tubercles, as is indicated by a comparison of the holotype (figure 2) with the paratype (figure 8).

This species is fairly common in outcrops of lower Taylor clays, and in the stratigraphic equivalents in all parts of the state.

Holotype.—No. 0–2496.1 Alexander Collections, collected at an exposure of lower Taylor clays in the north bank of Opossum Creek, about 300 feet east of the Waco-Taylor highway, at a point 2.0 miles southwest of Granger, Williamson County, Texas.

Paratype.—No. 0–2496.2 Alexander Collections, collected at an exposure of Brownstown marl, in a roadside ditch along the east side of the Paris-Commerce highway, at a point 2.9 miles south of Paris, Lamar County, Texas.

ORTHONOTACYTHERE POLITA Alexander, n. sp.
Plate 8, figure 7

Carapace small, elongate, quadrate in outline. Dorsal margin straight. Ventral margin convex downward, curving abruptly upward posteriorly to the short, blunt, compressed caudal process at the postero-dorsal angle. Anterior end broadly and evenly rounded, with narrow, compressed border. Widest and slightly inflated at ventral margin. A distinct, vertical sulcus slightly anterior to the middle divides the carapace into two subequal lobes. Surface of valves smooth, with glassy, polished appearance. Each valve bears eight strong, smooth tubercles, arranged exactly as in *O. scrobiculata*, described above. The ventro-lateral edge of each valve bears a narrow, compressed, blade-like keel or ridge, which curves upward at each end and terminates at about the median longitudinal line of the valve.

Length of holotype 0.53 mm., height 0.3 mm., width 0.24 mm.

O. polita occurs in abundance in some outcrops of Taylor clay immediately overlying the Pecan Gap chalk, but is entirely absent in other exposures at the same stratigraphic level. The species is not represented in the writer's collections from any other horizon in the Texas Cretaceous.

Holotype.—No. 0–2497.1 Alexander Collections, collected at an exposure of Taylor clays, in a shallow roadside ditch along the north side of the Forney-Rockwall road, 2.3 miles northwest of the intersection of the two main streets in the business district of Forney, Kaufman County, Texas.

PALEONTOLOGICAL NOTES

THE UPPER CRETACEOUS AGE OF THE ORBITOIDAL GENUS *GALLOWAYINA* ELLIS[1]

DOROTHY K. PALMER
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ABSTRACT

The type locality of *Gallowayina* was visited and a careful examination of the stratigraphy and fauna indicates the Upper Cretaceous age of the beds.

Gallowayina, a genus of orbitoidal foraminifera, was recently described by Dr. Ellis[2] from a collection of fossils made in Cuba many years ago by Mr. Barnum Brown. The holotype is reported to have come from the "Upper Eocene orbitoid series immediately overlying the Cretaceous, on the Anaya River 1 kilometer below Baños, Cuba."[3]

Intensive geological exploration of the island during the past four years has provided abundant fossil material from both the Upper Cretaceous and Upper Eocene. *Gallowayina* is a common and characteristic genus in the Upper Cretaceous fauna. It is also widely distributed geographically, having been found in four of the six provinces of the republic. The accompanying fauna comprises *Omphalocyclus macropora* (Lamarck), *Orbitoides palmeri* Gravell, Cretaceous echinoids, *Pecten* (*Vola*), rudistids and rudistid fragments and numerous small foraminifera among which are the characteristic Cretaceous genera *Gümbelina*, *Globotruncana*, *Planoglobulina* and *Pseudotextularia*.

The undoubted Upper Cretaceous age of *Gallowayina* at all known localities throughout its wide geographic range cast grave doubt on the Upper Eocene age determination of the type locality. The type locality was visited and careful collections were made.[4]

Gallowayina is abundant in the white marly limestone outcropping on the north side of Anaya River at the Finca Niagara road crossing, 1 kilometer west (downstream) from Baños de Ciego Montero[5] station on the United Railways of

[1] Published with permission of the Atlantic Refining Company of Cuba. See the following paper by T. Wayland Vaughan which points out that *Gallowayina* is a synonym of *Orbitoides*.—Editor.

[2] Ellis, B. F., *Gallowayina browni*, a new genus and species of orbitoid from Cuba, with notes on the American occurrence of *Omphalocyclus macropora; Amer. Mus. Novitates*, no. 568, pp. 1–8, 9 figs. in text, Sept 22, 1932.

[3] Ellis, B. F., *Op. cit.*, p. 4.

[4] The author is greatly indebted to Dr. R. E. Dickerson, Chief Geologist of the Atlantic Refining Company of Cuba, for his guidance in the interpretation of the stratigraphy of this locality and his constant encouragement of micropaleontological studies in Cuba.

[5] Baños de Ciego Montero is a classic locality of Cuban naturalists. One of the springs yielded the remains of the ground sloths *Megalocnus rodens* (Leidy) (or *Myomorphus cubensis* Pomel) and *Mesocnus browni* Matthew, the crocodile *Crocodilus pristinus* Leidy and the turtle *Testudo cubensis*. See De la Torre, Carlos, Osamentas fosiles econtrades en las casimbas de la Sierra de Jatibonico . . . *Revista de la Facultad de Letras y Ciencias*, Habana, 1910; Matthew, W. D., Genera and the new species of ground sloths from the Pleistocene of Cuba; *Am. Mus. Novitates*, no.

Havana branch line to Cienfuegos, Santa Clara Province, Cuba.

The topography of the country around Baños de Ciego Montero is almost flat or very gently undulating and the best clues to the underlying strata are found in the occasional river and railroad cuts. A finely conglomeratic rock (graywacke?) composed largely of igneous rock debris in a calcareous matrix dominates the terrain and outcrops in Anaya River for approximately a kilometer westward (downstream) from Baños. At this point there is a small cascade in the river formed by Cretaceous limestone. Fifty-five meters westward from the cascade the road to Finca Niagara crosses the river. The finely conglomeratic rock of igneous debris and interbedded pale-green siliceous tuff outcrop in the streambed and in the road at the crossing. Immediately to the westward the river has cut a small gorge through the Cretaceous limestone. At the road crossing the strike and inclination of the Cretaceous limestone and the underlying series of finely conglomeratic igneous debris rock (or graywacké?) and interbedded siliceous tuff may be clearly seen. Both are striking north 55° east and dip to the northwest, the former at an angle of 8 to 12 degrees, the latter from 40 to 50 degrees.

The only fossil found in the finely conglomeratic igneous debris rock was a fragment of echinoid spine. This is of value chiefly as an indication of the marine origin of the deposit.

In the road on the north side of the river the marly, highly fossiliferous white limestone is well exposed. The fauna comprises *Gallowayina browni* Ellis, *Meandropsina* n. sp., an *Operculina*-like rotalid (new genus), two types of echinoid spines (both of which have been found elsewhere in characteristically Cretaceous assemblages), *Pecten* (*Vola*), a few poorly-preserved small foraminifera and ostracodes, a poorly-preserved rudistid fragment and an echinoid. The generic assemblage is small but entirely Upper Cretaceous in aspect. There are no elements in it suggesting Upper Eocene age which might be interpreted as indicating a reworked Cretaceous fauna in an Upper Eocene deposit. The genus *Omphalocyclus*, listed by Dr. Ellis from this locality, was not found. Judging from the statement "These individuals represent the only occurrence of this genus and species in the western hemisphere. . . . Both specimens are of the megaspheric form . . . "[6] it was rare in the original collection from this locality. *Omphalocyclus* is, however, very common in the Upper Cretaceous in Cuba and accompanies forms as definitely Cretaceous in age as does *Gallowayina*.[7]

On the south side of Anaya River, stratigraphically above the white limestone is a small outcrop of soft yellow marl. No satisfactory dip could be obtained.

That the yellow marl lies stratigraphically above the white limestone is evidenced by the absence of outcrops in the river and the presence of large pools where the outcrops should appear. Between the cascade formed by the first outcrop of the Cretaceous limestone and the road crossing there is a large quiet pool in the river and beyond the gorge cut in the Cretaceous limestone just west of the road crossing the river opens into another large pool where the marl should have outcropped above the limestone.

The fauna of the yellow marl is likewise Upper Cretaceous in age. It comprises several species of ostracodes, *Exogyra*, echinoid spines similar to one of the types found in the white limestone, a small and very distinctive species of scaphopod (?*Hamulus*) which is common in Cuban Cretaceous assemblages at

511, 1931, and Brown, B., Some Cuban fossils; *Am. Mus. Journal*, p. 221, May, 1913.

[6] Ellis, B. F., *Op. cit.*, p. 6, 7.

[7] One of the most accessible localities at which *Gallowayina* and *Omphalocyclus* may be obtained in abundance is the northeast corner of Sitios and Franco Streets in the city of Havana.

many localities, *Operculina*-like rotalids, and occasional small foraminifera, among which are the genera *Gümbelina*, *Globotruncana* and *Planoglobulina*. Only three specimens of *Gallowayina* were found in the yellow marl. The most abundant foraminifer in the assemblage of the yellow marl is the operculine-like rotalid which was noted in the fauna of the white limestone. This new genus has been found elsewhere in Santa Clara Province associated with characteristically Upper Cretaceous genera of small foraminifera, the orbitoid *Orbitocylina* cf. *O. nortoni* Vaughan and rudistids.

No Eocene rocks were encountered in this immediate area and there is no evidence to support the suggestion that the fauna was derived by erosion of Upper Cretaceous rocks and deposited in sediments of Upper Eocene age.

The fauna of the marly white limestone is poor in species though rich in individuals of *Gallowayina browni* Ellis. The Upper Cretaceous age is evidenced not only by the faunal assemblage but, more satisfactorily, by its identity with assemblages in undoubtedly Upper Cretaceous strata in many parts of Cuba, where very frequently a greater diversity of genera and species has been encountered.

A NOTE ON *ORBITOIDES BROWNI* (ELLIS) VAUGHAN

THOMAS WAYLAND VAUGHAN
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Mr. Brooks Fleming Ellis has recently published an article entitled "*Gallowayina browni*, a new genus and species of orbitoid from Cuba, with notes on the American occurrence of *Omphalocyclus macropora*."[1] Unfortunately, *Gallowayina* is a precise synonym of *Orbitoides* d'Orbigny, genolectotype *O. media* (d'Archiac). The genoholotype of *Gallowayina*, *G. browni*, is closely related to *Orbitoides apiculata* Schlumberger, a species common in the Upper Cretaceous of south-central and southern France and at Maestricht, Limburg, Holland. Apparently Mr. Ellis did not compare his descriptions and illustrations with those of *Orbitoides*, otherwise he would have recognized that he was repeating in his characterization of *Gallowayina* the diagnostic features of *Orbitoides*. He says regarding the nucleoconch:

> In vertical section the nucleoconch may present various appearances, according to the orientation of the section, but in reality it is quadrilocular, the group of four chambers being surrounded by a heavy fibrous wall, with the fibers normal to the surface . . .
>
> In horizontal section the nucleoconch appears quadrilocular, the small initial chamber being followed by a larger kidney-shaped one and the two bounded on either side by a hemispherical chamber.

After the description of *G. browni* it is said that:

> This form appears to be the American analogue of *Clypeorbis mamillata* (Schlumberger). It differs from the European form in many important respects, however. The megaspheric nucleoconch of *Clypeorbis* is a trochoid spire, while that of *Gallowayina* is quadrilocular. Then, too, the American form is more conical than the European genus, and there is marked difference in the form and arrangement of the median chambers. Also the median zone of the Cuban form is more dome-like than that of *Clypeorbis*.

H. Douvillé says regarding the embryonic chambers of *Orbitoides*:[2]

> Cet embryon quadricellulaire caractérise les formes les plus anciennes *O. tissoti* (fig. 1); il se retrouve presque sans modification dans *O. media*, un peu plus récent, du Dordonien.

[1] *Am. Mus. Novitates*, 568, 8 pp., 9 figs., Sept. 22, 1932.

[2] *Soc. géol. France, Bull.*, ser. 4, vol. 20, p. 212, 1921.

Mais déjà à ce niveau il commence à se simplifier (fig. 4 à 9): trois des quatre cellules primitives s'atrophient progressivement, puis se fusionnent dès la période embryonnaire, de sorte que la protoconque devient biloculaire, et du type embrassant, une seule cellule probablement ayant conservé son noyau; cette modification caractérise *O. apiculata*, qui seul persiste dans le Maestrichtien, jusqu' à la disparition complète du groupe.

It should be noted that the atrophy and fusion of three chambers into one chamber does not invariably occur, as is shown by the figure of a vertical section through the embryonic chambers of a specimen of *Orbitoides apiculata* from Maestricht.

One of the diagnostic features of *Orbitoides* is the means of communication between the equatorial chambers.[3] The apertures for the protoplasmic stolons in *Gallowayina* are identical in their general features with those in *Orbitoides* and they are very similar specifically to those of *O. apiculata*, as the illustrations mentioned below show.

Mr. Ellis mentions *Clypeorbis*, apparently not realizing that the method of communication between the equatorial chambers in it is by means of minute perforations in the chamber walls, as in *Lepidorbitoides*, and that in this respect both *Lepidorbitoides* and *Clypeorbis* are strikingly different from *Orbitoides*, of which *Gallowayina* is a synonym.

The only other feature of *Gallowayina* that needs to be considered is its asymmetry. Mr. Ellis says:

The asymmetry is a striking character, manifesting itself not only in the external form of the test but in the internal structure as well, only the nucleoconch escaping its influence. One of the striking features of the internal arrangement is the large number of pillars on the flat side and, with the exception of the apical plug, their complete absence from the conical one; another is the flattening and rotating of the median chambers so that they merge with the laterals of the flat side, near the edge of the test; while the most peculiar feature of all is the doming of the median zone. All or none of these characters may be of generic significance.

[3] Douvillé, H., *Op. sup. cit.*, p. 213, figs. 10–12.

H. Douvillé says regarding *O. apiculata*:[4]

"Elle est également très abondante a Maestricht, dans les couches à Bryozoaires mais la elle est souvent dissymétrique, comme le montre l'échantillon figuré en coupe par Schlumberger (*loc. cit.*, pl. 8, fig. 6)."

Schlumberger's figure referred to by Douvillé shows apical pillars on the conical face of the specimen similar to the apical plug mentioned by Ellis.

Although *Orbitoides browni* is in many of its features very similar to *O. apiculata*, it is more robust than that species. At Maestricht *O. apiculata* and *Omphalocyclus macropora* are associated, as are *O. browni* and *Omphalocyclus macropora* on Anaya River near Santa Clara, Cuba.

Two species of *Orbitoides* are now known from Cuba. In addition to *O. browni*, there is the previously described *O. palmeri* Gravell, from a depth of 950 feet in a well near the village of Campo Florido, Havana Province.[5] The latter species is symmetrical and has affinities with *O. media*.

The specimens of *Orbitoides apiculata* and *O. browni*, discussed in the foregoing notes, are illustrated in the section on the Orbitoididae by me in Cushman's revised edition of "Foraminifera, their classification and economic use," second edition, August, 1933. The illustrations appear in the "Illustrated key to the genera of the foraminifera," on plate 40. The figures and their descriptions are as follows:

FIGS. 1, 2.—*Orbitoides apiculata* Schlumberger, Maestricht, Limburg, Holland. Two views of the same vertical section. 1, section through embryonic chambers, ×43. Fig. 2 shows the stoloniferous apertures, two of which are very distinct in the chamber of wall the middle chamber represented in the figure, ×ca. 65.

3, 4.—*Orbitoides browni* (Ellis) Vaughan, from Tarafa Railway Station,

[4] *Op. sup. cit.*, p. 217.

[5] Gravell, D. W., The genus *Orbitoides* in America, with description of a new species from Cuba: *Jour. Paleontology*, vol. 4, pp. 268–270, pl. 22, 1930.

Cuba. Two views of the same vertical section. 3 illustrates both the equatorial and lateral chambers, ×ca. 15. Fig. 4 shows numerous stoloniferous apertures, two can be clearly seen in each of the two chambers at the left, and there are others toward the right, ×40.

(Photographs by E. M. Thorp. Both thin sections are in the collection of the Scripps Institution of Oceanography.)

In the section on the Orbitoididae in Cushman's work mentioned (page 286), I have placed *Gallowayina* Ellis in the synonomy of *Orbitoides*, but without discussing its relation to other species of the genus.

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